COLLEGE OF ENGINEERING CORNELL UNIVERSITY

the Cornell engineer

APRIL, 1953

VOL. 18, NO. 7

25 CENTS

Tight reins in the stratosphere

FOR YEARS the performance of bombers and fighter planes at high altitudes has been seriously handicapped by "mushy" controls due to slackness in the cables.

That's because, when flying in the earth's upper atmosphere where it's sometimes as cold as minus 70°F., the aluminum airframe contracts much more than the carbon steel control cables. To take up the slack, all sorts of compensating devices were utilized. They were expensive. Were costly to maintain. They added cumbersome weight. Created potential lags in control response.

Now this problem has been solved. By the logical step of basically improving the control cable itself . . . by developing a steel cable that would contract and expand at practically the same rate as the plane's aluminum frame. It took fifteen years to do it but it was worth the time and cost. We called this improved cable, HYCO-SPAN*.

HYCO-SPAN Aircraft Cable, with a coefficient of expansion 50% higher than high carbon steel, and 33% higher than stainless steel, comes *closest* of any steel cable to matching the expansion and contraction of 24 ST aluminum alloy air frames.

Even without temperature compensating devices, HYCO-SPAN provides positive, responsive control that won't loosen or tighten up, that will remain free of lag and mushiness, and that prevents the development of plane flutter—no matter what the altitude, no matter how big the plane or at what speed the plane is flying.

In addition, HYCO-SPAN Cable, being non-magnetic, has no effect on sensitive airborne electronic equipment. Having the corrosion resistance of stainless steel, HYCO-SPAN stands up well in service in any climate. Its low coefficient of friction permits lower tension loads and improves stability.

HYCO-SPAN Cable is another example of the many interesting products developed and produced by United States Steel. If you're interested in becoming a part of a progressive organization after graduation, why not look into the opportunities with United States Steel? For more details, ask your placement director or write for the informative booklet, "Paths of Opportunity." United States Steel Corporation, Room 2810-S, 525 William Penn Place, Pittsburgh 30, Pa.

**Short for "high coefficient of expansion."*

USS

3-696

UNITED STATES STEEL

"True-or-False" Quiz on Business

Question	What Most People Believe	The Fact
How big are corporations' profits?	25% (or 25¢ out of each $1 of sales).	7%. In most years actually *less* than 7 cents of each sales dollar.
Who gets the largest share of the income of corporations?	Most people say the owners do.	Actually the workers—they get 86%.
Does war increase corporation profits?	Many people think so.	The facts are—NO. Compared to a good peace year, corporation profits on the sales dollar went down from 6.4¢ to 4.3¢ in the last war.
Do machines put men out of work?	Most people say yes.	NO. In the automobile industry, for example, one man and a machine do the former work of 5 men, yet 20 times as many men are employed. Machines well used reduce costs and prices which broadens markets and so provides more jobs.
Do top executives make too much?	Too many workers think, "If their salaries were divided among workers, our wages could be much higher."	If *all* the salaries of the three top men in the country's biggest company were divided among that company's workers, it would take each worker in that company about three weeks to buy one pack of cigarettes with his increase.
Should taxes on corporations be increased?	"Yes," say many. "Soak the rich."	Truth is that high taxes already take so much money which should be spent in keeping machines modern, that 43% of America's machines are too old to protect tomorrow's jobs.

So much falsehood has been spread about business by communists that workers in their own interest should promote the truth. The best interest of workers, business and all the people is the same.

* * *

Warner & Swasey is a group of men who work hard, respect each other, and enjoy the satisfaction of group accomplishment. If that sort of life appeals to you, write Charles Ufford for employment opportunities here.

WARNER & SWASEY
Cleveland
PRECISION MACHINERY SINCE 1880

YOU CAN PRODUCE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY MACHINE TOOLS, TEXTILE MACHINERY, CONSTRUCTION EQUIPMENT

Opportunity

knocks on many doors at General Motors

HOWEVER lofty your ambition, or specialized your technical training, you'll find opportunity behind a great many doors at General Motors.

There are good reasons why.

Our products range from automobiles and trucks to refrigerators and Diesel engines. In addition, as a leading defense contractor, GM makes everything from shells, bombsights and range finders to tanks and jet and Turbo-Prop engines.

Naturally, this diverse activity calls for a varied array of engineering talents—mechanical, electrical, chemical, metallurgical and industrial. And it calls for all the imagination and ingenuity a young engineer can supply.

Moreover, the environment at General Motors is especially conducive to advancement and success. For all work is decentralized among GM's 33 manufacturing divisions, its 111 plants in 55 towns and cities throughout the country. And although each division operates as an independent unit with its own engineering department, each can draw upon the resources of GM's central research and engineering laboratories.

Thus is combined the friendly, intimate atmosphere of a small organization with the scope, facilities—and opportunities—of a large one.

So a young engineer, who has what it takes, can take what General Motors has—and fashion a noteworthy career for himself in his chosen field. Many engineering graduates now in top jobs at GM can vouch for that.

Why not check with your College Placement Office and arrange for an interview with our GM College Representative the next time he visits your campus? Or if you prefer, write direct to us.

GM positions now available in these fields:

MECHANICAL ENGINEERING	ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING	INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING	BUSINESS ADMINISTRATION

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

You'll be at the head of the jet parade at Boeing

For long-range opportunities, it's hard to beat the jet aircraft field. If *you* want to get into this exciting branch of engineering after you graduate, get in at the head of the parade—at Boeing.

Through the fighter-fast B-47 six-jet bomber, and the giant new eight-jet B-52, Boeing has acquired more experience designing, flying and building multi-jet aircraft than any other company, either here or abroad. In addition, Boeing is the first American company to announce its entry into the jet transport field.

Engineering graduates will find in the aviation industry an unusually wide range of experience, and great breadth of application — from pure research to production design, all going on at once. Boeing is constantly alert to new techniques and materials, and approaches them without limitations. Extensive subcontracting and major procurement programs, all directed and controlled by engineers, afford varied experience and broad contacts and relationships.

Aircraft development is such an integral part of our national life that young graduates can enter it with full expectation of a rewarding, long-term career. Boeing, now in its 36th year of operation, employs more engineers today than even at the peak of World War II. Its projects include guided missiles, research on supersonic flight and nuclear power for aircraft.

Boeing engineering activity is concentrated at Seattle in the Pacific Northwest, and Wichita in the Midwest. These communities offer fine fishing, hunting, golf, boating and other recreational facilities. Both are fresh, modern cities with fine residential sections and shopping districts, and schools of higher learning where engineers can study for advanced degrees.

There are openings in ALL branches of engineering (mechanical, civil, electrical, aeronautical, and related fields), for **DESIGN, DEVELOPMENT, PRODUCTION, RESEARCH and TOOLING.** Also for servomechanism and electronics designers and analysts, and physicists and mathematicians with advanced degrees.

For further information consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Washington

BOEING

Wanted . . . A New Outlook

According to its constitution, the purposes of the Cornell Student Engineering Council are: "to coordinate the activities of the student organizations of the various schools in the College of Engineering; to provide a liason between the undergraduates of the College of Engineering and the Cornell Society of Engineers; to promote an esprit de corps, friendship, free exchange of ideas, and interest in the College of Engineering and the engineering profession." Since its organization in 1948, Council has done a commendable job of fulfilling these aims, though its activities have been characterized by a striking lack of communication with the student body it supposedly represents.

Few engineers are actually aware of Council's existence and fewer yet are familiar with its functions, despite the fact that almost almost all have shared the results of its efforts. Coordination of engineering society meetings, sponsorship of the annual Engineers' Day program and supervision of the Engineers' Lounge all fall under Council's jurisdiction and illustrate the broad scope of its activities. In addition, it brings together each year students and faculty members from all the schools in the College at the Engineers' Banquet, where the invisible barriers delineating the various fields of engineering education are at least temporarily broken. Most important of all, however, is the fact that Council stands ready at all times to receive students wishing to be heard on any matter pertaining to the welfare of engineering at Cornell.

The question naturally arises as to why CSEC has been ineffective in communicating with the undergraduate body. Part of the answer lies in the familiar apathy shown by students towards such campus organizations; part lies in Council's failure to adequately publicize its functions; and part lies in the manner by which Council members are elected.

The Council realizes its shortcomings and is at present taking steps designed to alleviate them. However, its function as a true representative of some two thousand engineers cannot be fulfilled unless it receives more cooperation and evidence of interest on the part of those who benefit from its existence. We have been missing a great deal by failing to realize the full potentialities of CSEC. There is no justification for the continuation of such a state of affairs.

D.S.

Where Are We Headed?

An examination of the editorials and articles in the magazines of the past few years, will indicate a rapidly growing trend in American thought. The scientist is looked upon as the greatest thinker of our age, the one we turn to for the answers to what is puzzling us in life. What are young men urged to do? Whom do we need most in the world? The answer is simple for most of us—scientists and engineers. In this way we can continue, at fast pace, our research and production. This is supposed to ensure that we keep "progressing."

Let us look a little more closely at *why* we are working so hard to produce more and better things. One answer to this would be that we are producing so that man can live a more enjoyable and beneficial life. Time-saving devices are invented so that people will be able to have more free time. Television, among other things, makes it possible for people to "drug" themselves, or escape this "extra time" that has been created.

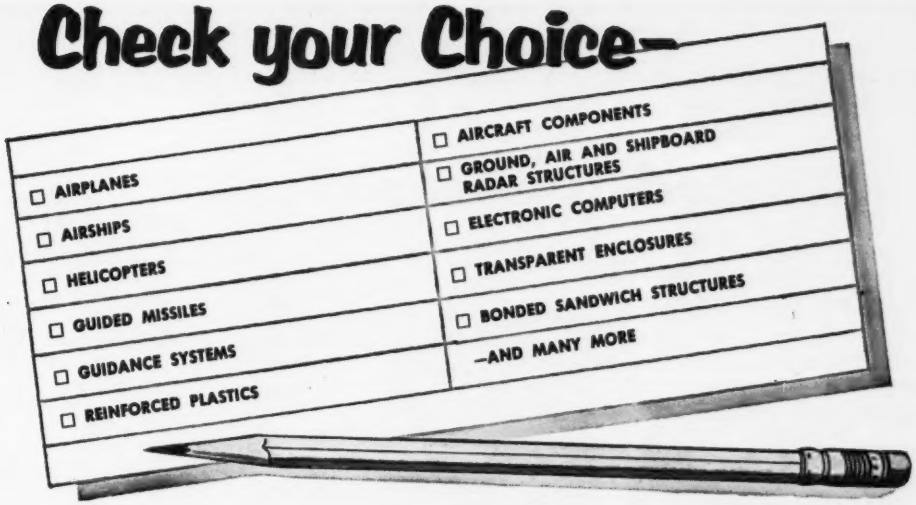
Perhaps the thought may seem strange and old-fashioned in this modern world, but we do not believe that the many entertaining gadgets that surround man today really make him happy. The petty quibbling and dissatisfaction in small everyday occurrences bears witness to this. It would be presumptuous to give a definition of what leads to true happiness and betterment of the world—but it is certain to include the following factors: love of other people as persons of equal right, a real concern for the needs of other individuals and for society as a whole, and selfless giving of ourselves to someone or some cause.

What, then, should we be pointing to? We have advanced with unbelievable speed in scientific discoveries, but we are centuries behind in knowing how to get along with each other. We have devoted time to the invention of all manner of devices, but we have omitted concentrating upon the most important thing of all: how to live harmoniously in the world. You might say that the reason for this is that the rest of the thinking and understanding in the world hasn't kept pace with science. Yet isn't this very factor reason enough that more people should devote themselves to making the world more as God intended it to be?

It seems that what we have is a misplaced emphasis. Of course we need science and engineering; these are vital to our living, but are they the end? Is this all? Maybe its time to reevaluate ourselves and our place in the world. Some serious thinking about our values and motives might give a different answer to the question of where we are heading.

T.S.F.

Check your Choice—



AND PLAN NOW TO GROW WITH GOODYEAR AIRCRAFT

No other company manufacturing aircraft and plane components offers you the wide variety of opportunity that exists at Goodyear Aircraft Corporation—an important contributor to America's air progress for more than forty years.

This is the company that pioneered in the use of high-strength aluminum alloys in this country—and leads today in light metals design and fabrication.

Goodyear pioneered with the first pneumatic airplane tire in 1910 — developed airplane wheels, disc-type brakes, the Cross-Wind Landing Wheel and other engineering advancements in plane components.

In World War II, Goodyear Aircraft became one of the nation's largest producers of aircraft—builders of complete military planes *and* of components for more than a dozen first-line ships. Today, too, GAC is still active in this field.

In lighter-than-air, Goodyear Aircraft is the world's largest builder of airships, including the new Navy N-type—largest nonrigid airship ever built.

Long the leader in its field, Goodyear Aircraft is once again vitally concerned with National Defense projects. But we go far beyond anything of the past. Today, our output includes complete airships as well as many aircraft components. But we are also active in many new fields—ranging from plastics fabrication and design to guided missiles and electronic computers.

This wide variety of production, together with our desire to build and maintain an outstanding engineering staff makes Goodyear Aircraft a good place to grow. You'll find unlimited opportunities for advancement in the engineering field of your choice.

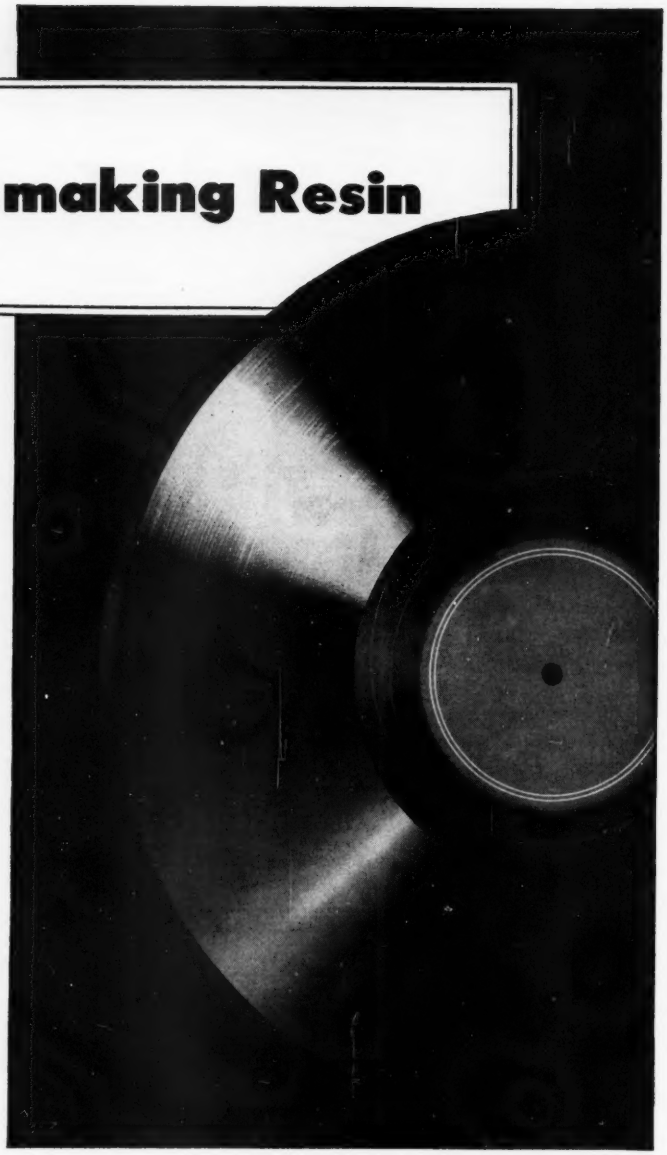
So plan NOW—take the first step by sending a brief resumé of your qualifications and experience. Or ask for an application blank and further information. *Address:*

Dr. K. Arnstein, Vice President of Engineering,
Goodyear Aircraft Corporation, Akron 15, Ohio.

GOODYEAR AIRCRAFT

GOODYEAR—The Company with COMPLETE Coverage of the Aeronautical Field

Record-making Resin



CHEMICAL PROBLEM...

. . . to find a low-cost, easy-to-get material for making phonograph records and other plastic products.

SOLUTION...

. . . Vinsol® Resin, one of many materials produced by Hercules in large quantities from the Southern pine. Low in cost, and easily mixed with other ingredients, Vinsol aids in the production of two types of records. In the standard 78 r.p.m., it replaces a substantial amount of imported shellac. Combined with ethyl cellulose or vinyl compounds, it offers many advantages in break-resistant phonograph records.

COLLEGE MEN...

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

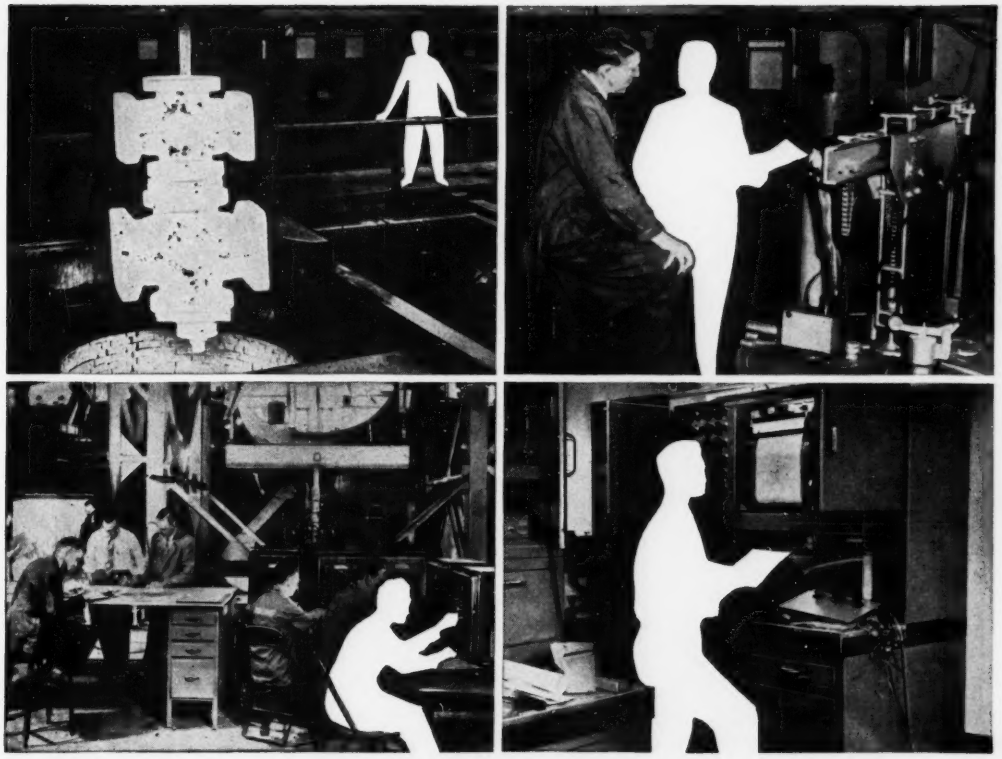
Hercules' business is solving problems by chemistry for industry . . .

. . . textiles, paper, rubber, insecticides, adhesives, soaps, detergents, plastics, paint, varnish, lacquer, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

HERCULES POWDER COMPANY Wilmington 99, Delaware
INCORPORATED
Sales Offices in Principal Cities

EC53-4



Engineers:

THERE'S A YOU MISSING IN INSTRUMENTATION

If you're still undecided . . . aren't sure which engineering career you'd like . . . still wish you could apply your ability to *more* than just one area of science and industry . . . the expanding instrument and controls field may offer just the career you've been looking for.

Vital to modern technological progress, the instrument field cuts laterally across every segment of industry and research. Here at Leeds & Northrup, for example, we help meet the instrumentation needs of steel mills, auto and aircraft plants, refineries, power generating and distribution stations, atomic energy plants, chemical and pharmaceutical companies. And these are but a few of our more important market areas.

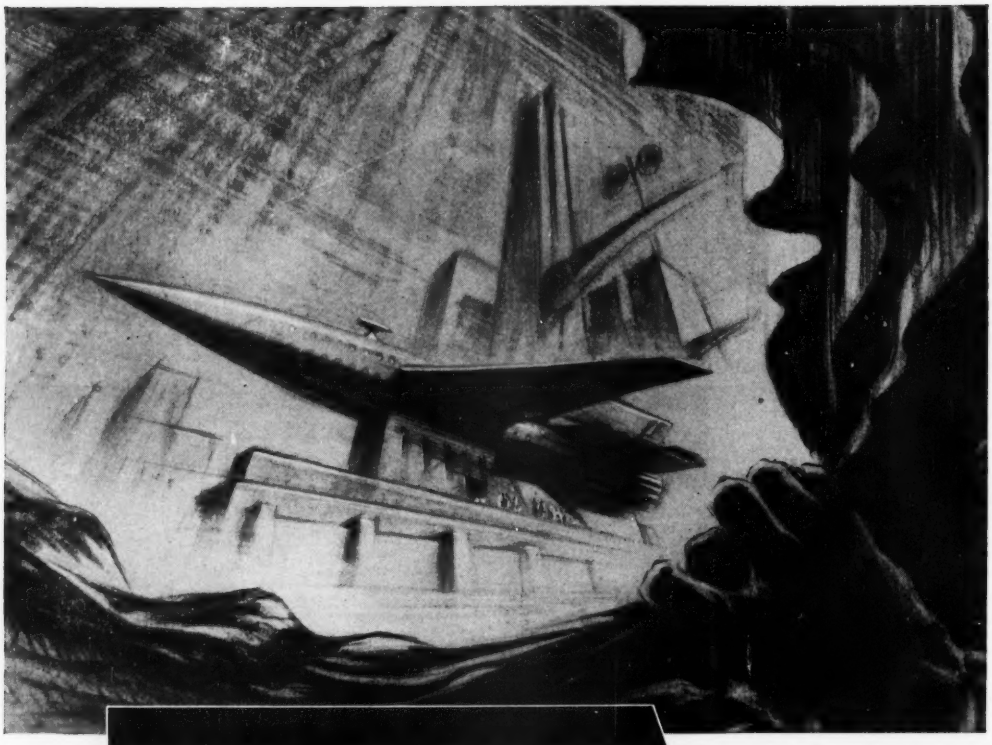
It's this challenge and variety . . . the feeling of playing an important, creative part in many enterprises . . . that makes working for L&N so interesting to engineers.

Our team includes engineers in the field, in product and application work, in research, manufacturing, inspection and other activities.

Why not investigate the *YOU* in instrumentation? Talk over the openings which now exist in our organization with our nearest District Office Manager. Or, if your prefer, write our Personnel Manager, 4915 Stenton Ave., Phila. 44, Pa.

LEEDS [N] **NORTHRUP**
instruments *automatic controls • furnaces*

Atlanta 5 Boston 66 Buffalo 2 Chicago 1 Cincinnati 2 Cleveland 15
Detroit 35 Hartford 7 Los Angeles 22 New York 17 Philadelphia 30
Houston 5 Pittsburgh 12 San Francisco 3 Seattle 1 St. Louis 8 Tulsa 3



BEYOND THE HORIZON...

Higher and higher the speeds; greater and greater the stresses.

To match needs which are still beyond the horizon, the engineer is increasingly urging the metallurgist to supply new materials.

The more efficient engines of today rely upon the use of temperature-resisting molybdenum-containing alloys; the jet engines of the future, with still greater stresses and higher temperatures, must rely even more upon Molybdenum.

Climax furnishes authoritative engineering data on Molybdenum applications.

Climax Molybdenum Company

500 Fifth Avenue · New York City 36 · N.Y.

Janice Button — editor-in-chief — EP '54
William H. Bentley — managing editor — EP '54
George Edwards — business manager — EE '55

◇

Publication Board

Edwin A. Leventhal — assistant editor — EP '56
John F. Schmutz — associate editor — ChemE '55
Alan F. Cohen — illustrations editor — CE '55
Milton Cherasky — treasurer — ME '55
Robert S. Arlook — circulation manager — ChemE '54
Richard Gons — advertising manager — CE '53
William C. Thurber — publicity manager — MetE '55
Robert Posner — office manager — ME '55

Editorial Board

R. P. Allen — ME '56
M. Lapp — EP '55
M. D. McIlroy — EP '56

◇

Business Board

J. L. Beckel — Arch '56
Y. Brazel — EE '56
R. K. Fisher — ChemE '57
F. B. De Gress — ME '57
G. Haunalter — CE '57
I. M. Jacobs — EE '56
R. J. Malone — ME '56
L. Pisnoy — CE '57
E. Weinthaler — ME '56

◇

Illustrations Board

D. Ball — CE '55
S. G. W. Beck — EE '56
D. Crook — Arch '56
E. Matzal — ChemE '56
R. C. Noyes — ME '55
R. L. Rosenthal — ME '53
R. L. Simon — EE '54

◇

Advisory Board

Dean S. C. Hollister

Technical Advisors

Prof. R. Y. Thatcher
Prof. W. H. Erickson

School Directors

Prof. C. R. Burrows — EE
Prof. N. A. Christensen — CE
Prof. F. H. Rhodes — ChemE
Prof. L. P. Smith — EP
Prof. H. J. Loberg — ME

Alumni

H. H. Williams, Jr. — C.E.'26
W. H. Hill — M.E.'22

Founded 1885

THE CORNELL engineer

APRIL, 1953 — VOLUME 18 — NUMBER 7

EDITORIALS 4

RAPID TRANSIT SIGNAL SYSTEM 15
by Herbert Edelstein, E.E. '27

PROJECT LR 18
by William J. D. Escher, ME '55

PRESIDENT'S MESSAGE 22

ALUMNI NEWS 23

THE DIAL TELEPHONE 26
by Charles B. Meyer, EE '56

NEWS OF THE COLLEGE 32

LETTERS TO THE EDITOR 33

RADAR PREVENTION OF AIR COLLISIONS 37
by James Q. Brantley, Ph.D.

PICTURE-BRIEF—PHOTO ENGRAVING 42
by Alan F. Cohen, CE '55

TAU BETA PI ESSAY 46
by Robert Conti, ME '53

TECHNIBRIEFS 50

THIS MONTH'S BRAIN TEASER 56

BOOK REVIEW 58
by Professor W. R. Sears

MECHANICAL ENGINEERS—CLASS OF '53 64

STRESS AND STRAIN 68

COVER: Teagle Hall under construction.

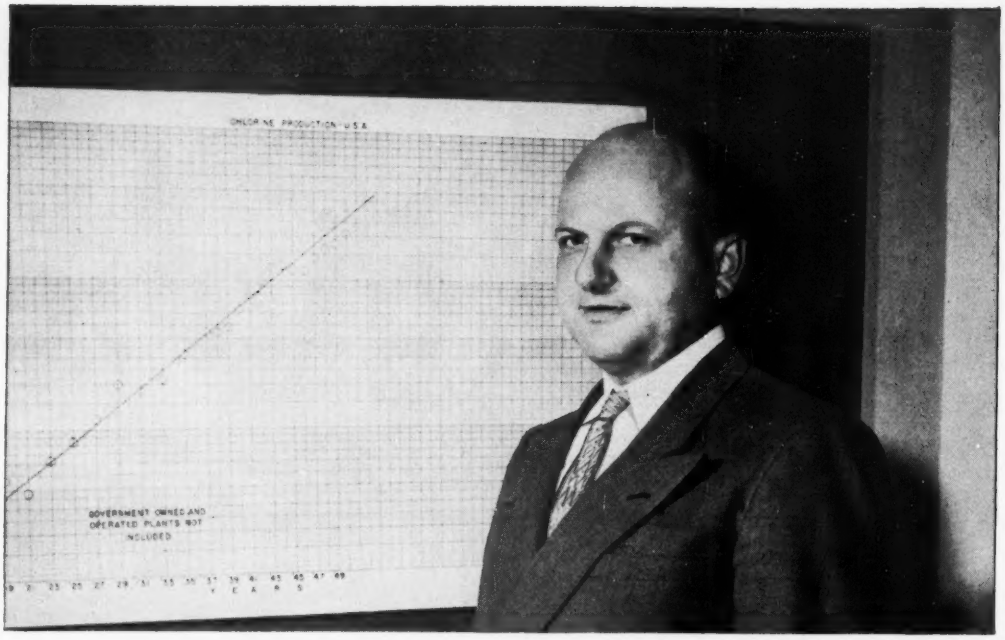
—Dave Ball

Member of The Engineering College Magazines Associated

Chairman: Prof. John Faustian, University of Nebraska, Lincoln, Nebraska
Publishers' Representative, Littell-Murray-Barnhill, Inc.
101 Park Ave., New York and 605 N. Michigan Ave., Chicago

Published monthly—October to May—by the CORNELL ENGINEER, Inc., Lincoln Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Entered as second class matter at the Post Office at Ithaca, N. Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular $2.00; with membership in the Cornell Society of Engineers $3.00 (See President's page); student $1.50; single copy $.25.



"...Give him the opportunity to grow"

This is Joseph A. Neubauer. He is an important member in the Columbia-Southern organization.

Right now, Mr. Neubauer is Technical Director of the Corporation. He has been on the move, upward, ever since he joined Columbia-Southern after graduation from college.

His progress is worth emulation. But initiative alone is not always the answer to a man's career. You can't launch an ocean liner in a mountain stream. Neither can a man travel far in an unprogressive, stagnant organization. A man needs freedom to put his ideas into action; he needs to move ahead without waiting for vacancies to occur from death or retirement. We believe Joe Neubauer's story will interest you and give you something to think about.

He graduated with a Bachelor of Science degree in Chemical Engineering from Case Institute of Technology in 1932. In 1933, a depression year, he joined Columbia-Southern as a production operator. Within a year, he was named shift foreman.

Shortly afterward, Joe was assigned to the Development Department to work out some problems involving the Soda Ash process. Following this he supervised the engineering and construction of Columbia-Southern's first chlorine unit at the Barberton, Ohio plant. He became assistant production manager at Barberton and, in 1942, was assigned to engineering and construction of the plant at Natrium, West Virginia.

He was elevated to superintendent of operations at Natrium and in 1946 moved to Pittsburgh as technical assistant to the Vice President. In 1949 he was named Technical Director of the Corporation.

Just this past year he was sent by Columbia-Southern to take the Advanced Management Program at Harvard University.

Joe Neubauer has some good advice to pass on to the 1953 graduate. "The main thing for a graduate is to select a company which will give him the opportunity to grow. In the Columbia-Southern organization, the road to top positions is open from many fields . . . whether it be sales, chemical engineering, electrical engineering or various other backgrounds. I would strongly advise any graduate who has an interest in the future to look into the opportunities at Columbia-Southern."

For further information, write now to our Pittsburgh address or any of the plants.

COLUMBIA-SOUTHERN CHEMICAL CORPORATION

SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY

420 DUQUESNE WAY, PITTSBURGH 22, PENNSYLVANIA

PLANTS: BARBERTON, OHIO • BARTLETT, CALIFORNIA • CORPUS CHRISTI, TEXAS • LAKE CHARLES, LOUISIANA • NATRIUM, WEST VIRGINIA • **DISTRICT OFFICES:** BOSTON, CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • HOUSTON • MINNEAPOLIS • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO

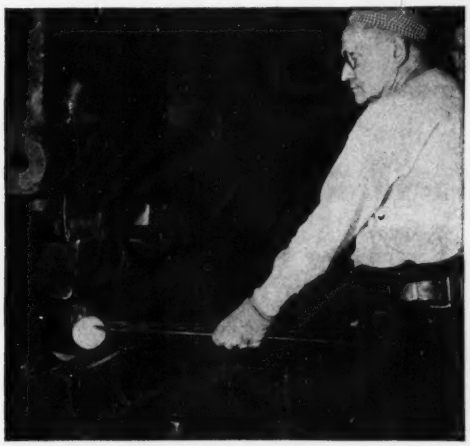
What's Happening at CRUCIBLE

about tool steel forgings

Whether 1½ pounds or 7 tons . . . forgings get the same sensitive handling

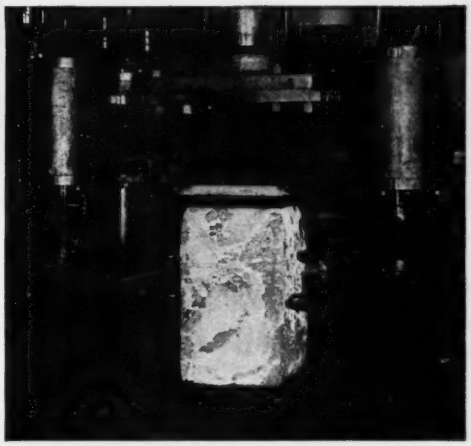
Crucible's reputation as the specialty steel leader is built on a devotion to the smallest detail . . . regardless of the size of the order.

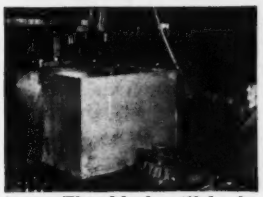
These forgings are good examples of Crucible specialists at work:



Rex M-2 High Speed Steel Disc Forging (1½ pounds)

Pancake forgings such as these are used extensively by small tool makers. Extreme care is taken in the preparation of the slug stock. The upsetting insures proper flow lines. Milling cutters, gear shavers and similar cutting tools that require maximum toughness, coupled with the best cutting ability, are made from these forgings.





CSM-2 Plastic Mold Forging (14,000 pounds)

This CSM-2 plastic mold steel forging was made from a 25,000-pound ingot. This block will be heat-treated and worked to produce a mold for the manufacture of large plastic parts. The finished weight of the forging is 14,000 pounds. And it is the largest mold forging yet produced by Crucible.

Engineering service available

Crucible's engineering service is geared to meet your research and development problems. If you use special forgings, or any special purpose steel, check with Crucible. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

52 years of Fine steelmaking

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

Preparing for specific responsible positions with Trane in sales, research and product design, these graduate engineers are attending a streamlined six-month training course at full pay. This interesting course moves rapidly and adapts the graduate's knowledge of engineering to the position he has chosen.

Trane Offers Engineering Graduates

OUTSTANDING OPPORTUNITIES IN AIR CONDITIONING

Qualified graduate engineers can step quickly into an interesting and prosperous career in the rapidly growing field of air conditioning. The Trane Company, leading manufacturer of air conditioning, heating, ventilating and heat transfer equipment, is seeking graduates for responsible positions in sales, research, product design and production.

Those selected will join the Trane Graduate Training Program in La Crosse at full pay. Each man will receive a specialized course to assure personal success in the position he has chosen.

He will learn how Trane equipment is used in jet aircraft, tanks, submarines, ships, skyscrapers, factories, industries, homes and buildings of all types. He will see how rapidly air conditioning is becoming a necessity . . . how it is destined to become a standard requirement in homes, automobiles, schools, offices . . . everywhere.

Graduates move quickly into responsible, well paid positions. Men who joined the company through this training program include the president and numerous company officers, managers of most Trane sales offices and home office sales divisions.

Trane's record has been one of steady growth and leadership for nearly forty years, during both peace and war. Today, new Trane products are being developed constantly . . . creating new departments and promotions . . . assuring continued growth and business opportunities.

For an outstanding career in one of the fastest growing industries, consider your future in air conditioning with Trane. Write immediately to Milton R. Paulsen, Training Department Manager, for the brochure "Trane Graduate Training Program". Next six-month class starts in July.

WHAT OTHERS SAY ABOUT TRANE

How much can graduates of their training program earn? What about competition? Is Trane strong financially? Does the company offer outstanding opportunities to young men?

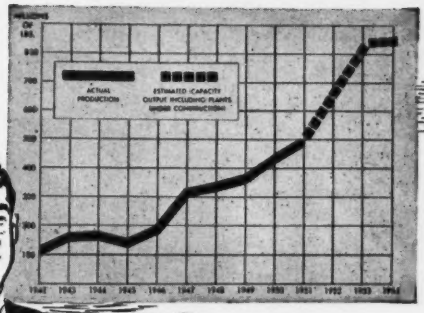
For the unbiased answers, read FORTUNE magazine's report on Trane in their August, 1951 issue. Your library should have a copy. A reprint of this report is included in the "Trane Graduate Training Program" brochure which is in your Placement Office.

TRANE

THE TRANE COMPANY • LA CROSSE, WIS.

Eastern Manufacturing Division, Scranton, Pennsylvania
Trane Company of Canada, Ltd., Toronto, Canada
Sales Offices in 85 United States and 14 Canadian Cities

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING EQUIPMENT



Reynolds expanding production —historic chapter in 33 years of continuing growth.

A Fertile Place for Careers to Grow...

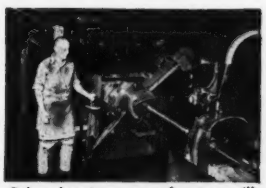
A broad vista of opportunity opens up for college graduates who come to work for Reynolds. The phenomenal rise of the Reynolds Metals Company, known throughout business and industry, is clearly depicted by the above chart. The five-fold expansion in total production of aluminum ingot alone spells broad opportunity. Add to this the vast and productive fabricating facilities of Reynolds —in themselves an enterprise of considerable proportions—and here indeed is a fertile field for any ambitious engineer.

From bauxite mining through metals refining and fabrication to application engineering, sales and marketing, Reynolds offers broad career opportunities. Operating 27 plants in 13 states, and still expanding, there is virtually no limit to what can be accomplished by a capable graduate engineer.

Preliminary orientation in production and sales...direct on-the-job training...liberal insurance, hospitalization and retirement programs...these are all parts of a sound personnel policy maintained at Reynolds.

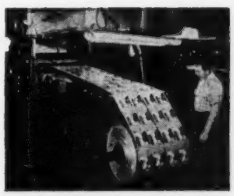
For important information on "your future in Aluminum," *mail the coupon.* If you are definitely interested now, write direct to General Employment Manager, Reynolds Metals Company, 3rd and Grace Streets, Richmond 19, Va.

Settling tanks, where impurities are separated from sodium aluminate

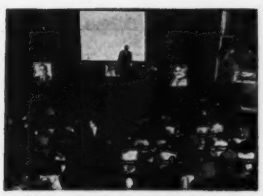


Tube drawing, one of many mill operations at Reynolds

REYNOLDS ALUMINUM



Foil—for many uses, including colorful, protective packages and labels; also famous Reynolds Wrap.



Full color movies tell the fascinating story of Reynolds Aluminum. 16mm films available for group showings.

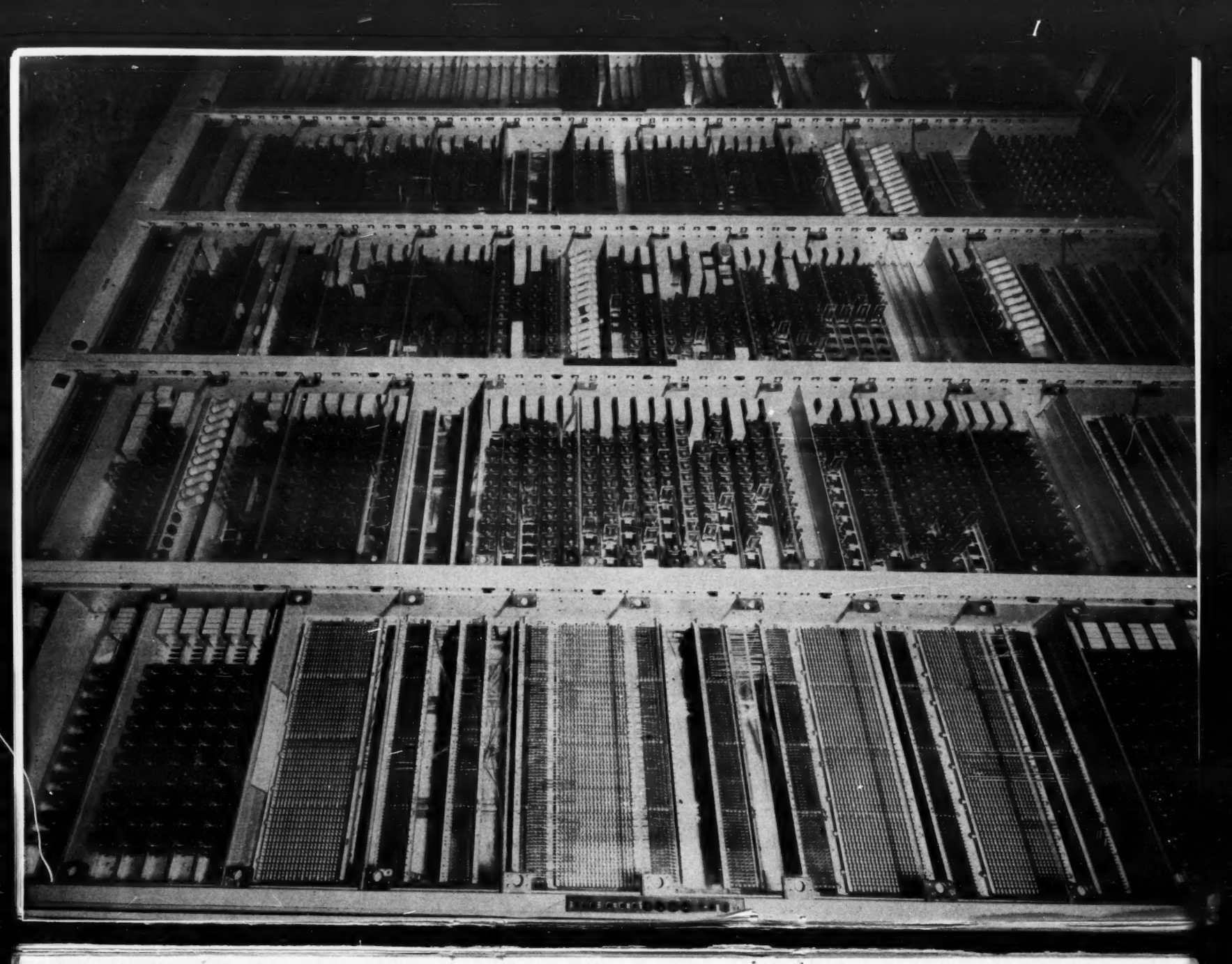
Reynolds Metals Company,
Employment Dept.
Richmond 19, Virginia

Please send me, **FREE**, your 96-page booklet "The ABC's of Aluminum"; also the 44-page book, "Reynolds Aluminum ... and the Company that makes it."

Name_____

Address_____

School_____ Class_____ Course_____



Rapid Transit Signal Systems

By HERBERT E. EDELSTEIN, E.E. '27

Signaling of a railroad has been too often an afterthought, and has sometimes been treated as "one of those necessary evils" which must be included in a modern railroad installation but which is not deserving of more than cursory attention. The subject is almost never mentioned in undergraduate courses and is seldom touched upon in graduate courses.

Nevertheless, the intense signaling of rapid-transit passenger roads (such as the subways of New York City, where 10-car trains, each carrying 2,000 to 3,000 passengers, are operated at less than 2-minute headways to transport nearly 2½ million riders in about two hours) is deserving of close attention by engineers, and is one of the most interesting and diversified engineering fields. While signaling is in some respects a highly specialized field and the opportunities in it are therefore more limited than in some other fields, the principles of signaling are broad enough and sufficiently wide in potential application to warrant careful study by many whose specialization will eventually lead them elsewhere.

Track Circuit

The purpose of signaling is to provide optimum use of a particular track with a degree of safety from collision which depends on the use to which the track is to be put; in the case of purely passenger railroads, the degree of safety must be comparable to that incorporated in the design of a large structure such as a skyscraper or suspension bridge. Signaling accomplishes its purpose by:

(1) providing means of detecting the presence of a train anywhere on the track to be protected, and

(2) transmitting that intelligence to the operators of trains (motormen) and to those responsible for the maintenance of schedules and the routing of trains (dispatchers and towermen), and

(3) enforcing upon those personnel operation of trains and control equipment in accord with the transmitted intelligence.

The presence of trains upon a track is detected by means of track circuits. One of the running rails (as distinguished from the third rail on electric roads) is divided into sections or blocks by means of insulated joints which effectively insulate two butting sections of rail from one another (in some installations, both running rails are so divided). The ordinary rail joint is not a very good electrical connection, so the rails are made electrically continuous between insulated joints by connecting copper bond wires to the rails on both sides of each ordinary joint. Standard rails are 33 feet long on rapid transit roads, and 39 feet long on interurban roads, whereas the spacing of insulated joints may be up to 1,500 feet on the former or 15,000 feet on the latter (if not electrified).

The rails are used as a transmission line (see Figure 1), a source of energy being connected to one end of the track circuit and a receiver (relay) being connected to the other. The relay receives energy when the track circuit is unoccupied, and is short-circuited by the train wheels and axles when a train is present. The relay thus serves as the detector of the presence of a train within the limits of the track circuit. The resistances shown in Figure 1 serve a twofold purpose; the one at the "feed" end limits the short-circuit current through the source to a value within its capacity when a train is present, while both together limit undesirable stray currents to tolerable values. The complete treatment of the track circuit is subject matter enough for several papers; it will not be attempted here.

Having detected the presence of a train, it is of primary importance to transmit this intelligence to the operator of the following train. The circuits for the transmission of this intelligence (which, incidentally, employ the "fail safe" principle throughout) are not properly a part of this discussion, but the means are. On modern rapid-transit roads, colored roadside signals of fixed location are used. These signals display red for stop, yellow for caution, and green for proceed.

ABOUT MR. EDELSTEIN

Herbert E. Edelstein is at present with the Municipal Civil Service Commission of New York City. He graduated from Cornell in 1927 and got a position with the United Electric Light and Power Co. of New York City in the Meter and Test Dept. From 1929 until 1943 he was employed by the Board of Transportation as an Electrical Engineer mainly concerned with the operation of railroad signals. He has taught various technical subjects at evening sessions of City College of New York and was at one time employed by a private technical school to instruct in electrical and related courses. His long experience with electricity and rapid transit signaling systems prompted him to write this article on the design and operation of safety signals for New York's vast transportation system.

To meet the requirements of safety and track use, one or more red signals must be displayed behind the rear end of a train, one or more yellow signals should precede the reds, and then there should be at least one green signal if the progress of the following train is not to be interfered with.

Figure 2 shows the minimum number of signals that should separate two trains if the preceding

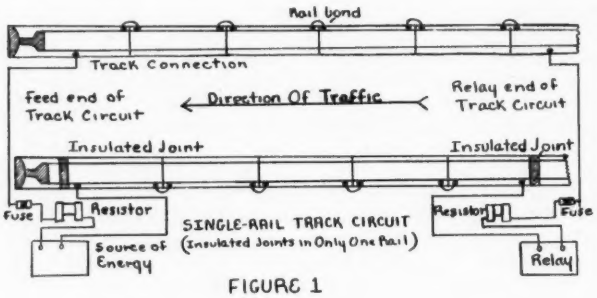


FIGURE 1

Fig 1. **Use of rails for transmission in railroad signal systems**

conditions are to be complied with. In this sketch, the trains are assumed to be operating at a fixed headway and at the same average speed. The product of speed and headway (in appropriate units) gives the distance H. To provide adequate safety, signal No. 3 must be located stopping distance plus a safety allowance behind the preceding train, and means must be provided to enforce the stop indication. In order that the following train be not interfered with, a green signal must be displayed at least the sighting distance D in advance of the following train need not slow must be such that the operator of the following train need not slow down as he would if he encountered a yellow signal at the same distance. The derivation of the formula shown in Figure 2 should now be obvious. It should be noted that the distance S is the *maximum average* signal spacing for the operating speed and headway under consideration.

(The stopping distance used on the New York City Transit System is equal to the emergency braking distance required for the maximum speed attainable at the location under consideration multiplied by the factor 1.35. The sighting distance D is taken as 50 to 100 feet, depending on the speed and other assumed and known operating conditions. The stop indication is enforced by a mechanical arm associated with the signal; when the signal is red, the arm assumes a position such that it will engage a "tripper" on the forward truck of a train passing the red signal, thus applying the brakes in emergency. Here too, the "fail safe" principle is applied; the stop arm is held in the clear position by the application of energy, while a spring brings the arm to the tripping position when energy is removed.)

Spacing Factors

With the foregoing in mind, let us now consider the factors which lead to deviations from spacing S, and those factors which influence the selection of locations for signal installations. The two principal factors (for a given headway) are the maximum speeds attainable by trains and the corresponding required braking distances. A little thought will show that these two, taken together, determine whether S provides the desired degree of safety. For example, if the design headway is 90 seconds and the assumed operating speed is 20 M.P.H. (a common combination in rapid transit work), and we take the sighting distance to be 100 feet while the maximum train length is 600 feet, then S turns out to be nearly 650 feet. If this distance is taken to be 1.35 times the maximum braking distance, the maximum braking distance must not exceed 480 feet if our standard of safety is to be observed. If the speed at any point is such as to require a greater braking distance, special treatment is required, or the headway may not be operable.

Thus it can be seen that any element which affects either speed or braking distance will have some influence on signal spacing. There are a large number of these elements, such as rate of acceleration, running and braking characteristics of the rolling stock, passenger load, grades, curves, and a variable called train resistance which includes friction of the air, rolling friction of wheels on rails, and bearing, brush, and gear frictions, not to mention flange friction. In addition to the preceding factors which exert a direct influence on speed and braking distance, there are those factors which influence the operations of trains, such as locations of stations and special work (switches, drawbridges, etc.), required length of station stop, operating rules relating to power economy, and the characteristics of the signal equipment itself (which in-

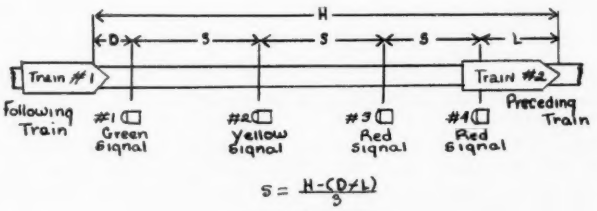


FIGURE 2

Fig. 2. **Shown above is the minimum number of signals which should separate two trains.**

cludes the distances at which signal indications are discernible and the time required to change from one aspect to another.)

There are a number of miscellaneous but highly important factors which include, among others, the maximum length of train to be operated, the number of different types of rolling stock that will be involved, and the maximum length of track circuit that will be dependable under the operating conditions. This last factor depends, in turn, on the sensitivity of the relay used, the average and extreme climate and maintenance conditions, the track construction, the method of handling return propulsion current, and the maximum traffic density of all tracks of the line.

A number of other factors must be considered, including the locations of entrances to underground enclosures adjacent to the subway structure, the locations of rail joints, clearances for maintenance forces, and the locations of tunnel lights.

Finally, the characteristics of the human beings who operate the trains must be considered; for example, no two motormen will react in the same way to the same set of conditions, and one individual may react differently to the same set of conditions at different times.

At all times, the signal engineer must bear in mind that economy in first cost and maintenance demand that signal equipment be kept to a minimum, but not at the cost of interference with train movement and consequent increased wear on rolling stock and roadway or possible increased schedule times requiring a greater number of cars and crews to operate the desired headway.

The actual job of laying out signals is done by combining all the known and assumed factors in their proper relationships on a "working diagram," the details of which are too involved for discussion here. It may be interesting to note how certain of the factors discussed affect signal spacing and location by citing some specific examples.

1. On rapid transit roads it is always desirable to have a signal located a short distance past the leaving end of a station so that the motorman will be informed of track conditions before he leaves the station. At headways of two minutes or less it is also necessary to have a signal a short distance before the entering end of the station, which, incidentally, must be long enough to accomodate the longest train to be operated. These signals are indicated at L and E, respectively, in Figure 3. It can be seen that these two locations are influenced by station locations and maximum length of train.
2. Once a train is permitted by the signal system to leave the station, it is clearly desirable that the signal system should not again stop the motion of the train until the rear end of the train is a sufficient distance past the station to permit the following train completely to enter the station. This principle is particularly important on rapid transit roads where the fact that a train is stopped partially in or out of a station may have an adverse psychological effect on the passengers and may, indeed, result in physical injury. Referring once more to Figure 3, C is the point beyond which the rear end of a train must pass before signal E will clear to permit the next train to enter the station. Obviously, if the preceding principle is to be followed, signal F must be located at least the length of the longest train past location C. Here again, it is the maximum train length which influences the choice of a signal location.
3. Since the stopping of a train at a station definitely interferes with the uninterrupted running of its follower, closer spacing of signals is generally required in the approach to stations than is required in the major portion of a run, except when the headway is relatively great. The longer the station stop, the greater will be the interference with the following train. In the last analysis, length of station stop determines the minimum headway which can be operated with a given type of rolling stock. For example, on the New York City Transit System the minimum headway that can be operated with full-length trains and a station stop of 30 seconds is about 85 seconds. A little thought will show that when headways are shortest, station stops tend to be longest because minimum headways are operated during periods of maximum passenger travel. The signal engineer must make the best possible compromise between these two conflicting conditions by designing the signal installation for an optimum value of station stop based upon records of operating roads and the engineer's knowledge of equipment and passenger characteristics. Obviously, if too large a value is assumed the signal installation will be costly, while too low an assumed value may result in an installation which cannot handle the traffic, necessitating subsequent costly alternations.

The foregoing three instances may give some slight insight into the effect of the various factors discussed on signal location and spacing. It is hoped that the undergraduate will have gained not only an exposition of certain principles and the confirmation of his belief that his grounding and fundamentals must be thorough, but will see in this explanation one more reason for intensive study of human nature because, in the last analysis, all his designs will be for the use and benefit of human beings.

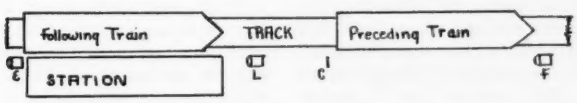


FIGURE 3

Fig. 3. Signals used in the proximity of stations on rapid transit roads.

PROJECT LR

By WILLIAM J. D. ESCHER, ME '55

The time is May or early June of this year. A gleaming white missile with black markings on its cruciform fins stands poised for launching at the bottom of a thirty-foot guiding track pointed straight up. Compactly enclosed within the sleek six and a half airframe is the heart of the missile, the liquid-fuel rocket powerplant and its related propulsive system, now thoroughly checked out behind the concrete wall of the static firing stand. A complex electro-mechanical and electronic array awaits its operating function in the stabilization and telemetering phases of the ensuing flight test. Personnel are busily occupied in final checkouts of all the equipment that will be utilized in the program.

It would seem almost as though a scaled down version of the White Sands Proving Ground had somehow been transplanted to this desolate area in New York State. But this test is not sponsored by the government, nor does the missile bear a simulated high-explosive warhead; it is the long-awaited finale to the Cornell Rocket Society's ambitious program of liquid-fuel rocket development—Project LR.

Having moved up as close as the rope fence will permit, we direct our attention to the last-minute preparations for the launching. The movable control surfaces connected to the servo system within are carefully aligned, the gas-pressure driven gyro is given a final electrical continuity check before the streamlined conical nosepiece is locked down over it, and the parachute door is secured. Immediately after the signal is given to commence fueling operations, the spectators are cleared from the immediate launching area and take their places at one of the remote observation points. A little less than ten pounds of fuel mixture, 75% ethyl alcohol and 25% water, are funneled into the oblong steel fuel tank which is then sealed for pressure. Ten pounds of liquid oxygen are then pumped into a similar oxidizer tank which immediately becomes frost coated. A liquified gas at approximately -300°F presents more than one tricky handling problem. Much of the liquid evaporates on contact with the relatively "hot" tank, as the spout of white vapor from the vent port indicates. Finally, the tank is topped and the safety pop-off valve is clamped down, set to blow at 450 pounds per square inch. This propellent combination is identical with that used in the V-2. The servicing hatch in the rocket's skin is closed, and after the main pressurizing valve is opened, the men trot back to the safety of the sturdily constructed blockhouse from which the actual firing operations will commence.

Test Director

The test director makes a final check to see that everything is in order and all personnel under cover; the several distant observation points from which the missile's flight will be tracked optically are contacted by field telephone. Finally the order is given: "Commence firing operations."

A switch is thrown; a brillant flame appears beneath the missile —the ignition flare. Another switch, and the shrill whine of the gyro accelerating up to speed is heard. An actuating motor alongside the rocket's power bay hums into action driving the main propellent valve open by degrees, so that combustion in the firing chamber does not commence with explosive violence. The motor catches! A roaring sound fills the air as a yellow-white flame cascades against the blast deflector, shortens and increases its intensity until a red light on the control console indicates the full-open position of the valve. An instantaneous check is made to see if the operation is proceeding as scheduled; if it is not, the valve actuator can be reversed and the firing stopped. Beyond this point the motor will cease firing only when its propellent supply is exhausted. Another switch uncages the gyro, withdraws the pressurizing supply, and snaps the valve actuator back free of the missile. From here on the axis of rotation of the gyro rotor, spinning at over 30,000 revolutions per minute, will be the reference axis about which the vehicle will stabilize.

A split second later the release solenoids are energized and the rocket mounts briskly up the guide

rails until it is in free flight, unrestrained by any form of exterior guidance. The two-hundred pounds of thrust developed by the rocket motor accelerate it against the opposing forces of gravity and air resistance, approximately two "g's". Visual tracking devices are aimed upward to follow and record the flight path of the vehicle. A detectable oscillatory motion about the vertical indicates that the stabilization system is functioning. A small radio transmitter within the missile, fed by signals from several instruments, sends data on the vehicle's attitude, acceleration, velocity, and servo operation, as well as the operation of intermittent devices, such as the parachute release and a small camera which is taking sequence pictures of the ground.

All this has occurred in a little over twenty seconds. Now the rocket is nearly a mile up and is traveling at over three hundred miles an hour—vertically upward. The sudden subsidence of sound as heard from the ground indicates the exhaustion of propellent; the rocket now enters the free coasting phase of the flight, but still it moves upward, trading its small fortune of kinetic energy for additional altitude. When gravity finally wins out, the vehicle's arrow stability points its nose downward and the descent to earth begins. If this headlong rush were to be left unchecked, the potential yield of any salvage would be practically nil, and the safety of those below might be endangered as well. For this reason a parachute blossoms from the nose section, slowing the descent to a rate consistent with minimum damage on landing. Touchdown occurs less than two minutes after the commencement of firing operations.

Aims of The Project

The test just described will be the culmination of a project that was undertaken by the Project Committee of the Cornell Rocket Society last October. The project has three aims:

(1) Development, through the design, construction, and testing stages of the several functional systems necessary for the rocket's operation.

(2) Prediction of the flight characteristics and performance of the rocket prior to testing.

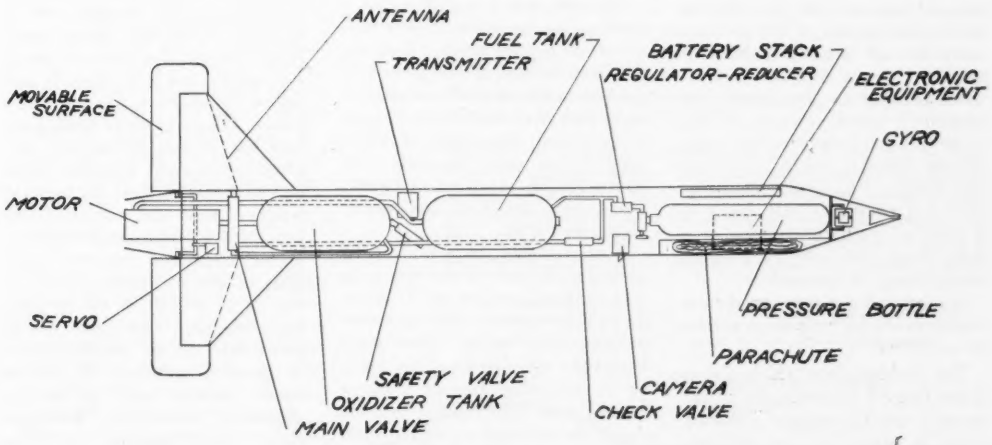
(3) Measurement and correlation of the actual flight program with that predicted.

Project Administration

The Project Committee, besides the chairman, consists of four groups: Propulsion, Airframe, Stabilization, and Instrumentation. The two heads of each group are responsible for the complete development and installation of one of the major vehicular systems. Each group is in turn broken down into sections, each of which carries out the development of a single component function. For example, under the Propulsion Group we find the Propellent Valve Section. The number of men in each section depends principally on the magnitude of the development; currently two men are in the Parachute Section, while the Servo Section is composed of five men. One of the advantages of this system is that, to a great extent, the project personnel can carry out their work on their own time.

Propulsion System

The rocket will be propelled by the two hundred pound rated thrust LR-2 motor, which at this writing, is scheduled to go into production very shortly. The motor is approximately three inches in diameter and ten inches in length. It is designed to consume propellent at the rate of about a pound a second and operate at a chamber pressure of three hundred pounds per square inch. In conjunction with another rocket project being carried out currently under the Machine Design Department of the School of Mechanical Engineering, two versions



of this motor are being developed, one of low-carbon steel, possibly with a stainless steel nozzle, and the other of aluminum. The only major difference between the two will be in the provision of regenerative chamber cooling.

A series of LR-2 motors will be constructed such that faulty points of one, as revealed by actual static firing tests, can be appropriately treated in the design of the next in the series. The aim of this procedure is to develop a successful and reliable motor which can be adapted as the powerplant of both the LR and the fifth-year engineering projects.

In the meantime, although it has revealed certain design faults, the smaller LR-1 motor is to be given a second static firing test on March 14. The equipment and procedures used for the first test, held last December 17, will be vastly improved for the ensuing trial. Although the December test was a "teething ring" for the Society in as much as a great deal of experience was gained, it was functionally inconclusive.

The Society's static testing station, located about one hundred feet to the south of the General Electric building at the Mohawk Airlines airport, consists basically of a concrete and steel stand and protecting wall to which the motors are affixed when operated for a performance determination. Some twenty-five feet away is a wood reinforced and roofed wall, behind which observations of the tests are made through a one-inch horizontal slot.

In addition to the motor, the propulsive system consists of the propellent and pressurization tanks, various types of valves, and lines and fittings. The design, construction, and testing of such items as a pressure regulator-reducer, or a main propellant valve, are major undertakings in themselves.

A simplified run-down on the operation of the LR propulsion system is as follows:

The ignition flare which directs a hot flame into the nozzle of the motor is ignited remotely. The main valve is opened by an actuator, pressurizing the tanks with a regulated gas supply from the pressurization tank. This forces the propellants through the lines where the liquid oxygen and alcohol (after it passes through the cooling jacket) stream through injection orifices impinging on the chamber, and react in a high order combusion process. The exhaust stream is accelerated to a velocity of over one mile per second in the nozzle. The net result is thrust.

Airframe

Take the propellant tanks, the pressurization bottle, and the rocket motor; place them end to end and connect all valves and lines. Surround this aggregate with electronic equipment, a parachute, gyro, servo, and batteries with all their related wiring. We still are far from having a vehicle for flight testing; we lack the airframe. The LR airframe can be conveniently broken down into three catagories: structural frame, skin, and control surfaces.

The first of these serves to hold the functional components of the missile rigidly in alignment under the stresses developed in flight. A frame of long-grained spruce and plywood has been completed and is currently undergoing strength tests. This type of construction gives high strength in compression, the major type of stress that will be met under flight conditions, for very low weight expenditure. If it does not prove suitable, another, probably of light alloy tubing or channels, will be substituted for it.

The skin, which is required for a low-drag configuration, is to be rolled out of aluminum sheet from ten to fifteen thousandths of an inch in thickness. The conical nosepiece is to be formed of thin lucite, or spun of aluminum, depending on which type proves most practical. The motor fairing, made up of twenty thousandths aluminum, has already been constructed.

Four triangular fixed fins are attached at the base of the missile. to each of these is hinged an "L" shaped movable surface which is driven by the servos within. These units have been completed and are made up of very thin aircraft plywood formed over heavy balsa formers. Again the strength to weight ratio is extremely high.

Stabilization

If the stabilization system functions correctly, the flight path will be a curvilinear oscillation of varying amplitude about a vertical reference line. This flight characteristic is due to the simple right-left, off-on type servo system being incorporated in the missile because of its combined simplicity and light weight.

Here is how it works: If the rocket moves off course a segment switch connected to the axis of the gyro will close, energizing a relay which will in turn cause the servo to actuate the control surface at an angle to the windstream, thus creating a correcting moment which swings the rocket back to the vertical course. In this manner the missile will be automatically stabilized about the yaw and pitch axes, or the north-south and east-west lines. No provision is being made for roll correction about the axis of the cylindrical body, except for prior careful alignment of the fixed surfaces.

Two types of servos are being concurrently developed; the one that proves itself superior will be used. The electro-mechanical type is made up of a very small six-volt d-c permanent magnet motor, which drives through a gear train of 2700 to 1 reduction ratio. The output speed at rated voltage is about 20° per second, and the torque is such that the last gear stage cannot be stopped with the hand. The whole is extremely compact and weighs only a few ounces. The other type is pneumatically actuated and is currently in the early design stage. It will consist of a two-way piston and cylinder fed by electrically controlled valves from the main propulsive system pressure tank. Each type has distinct advantages, and, when development is further along, we will choose the best one from the results of tests with simulated control surface aerodynamic loads.

One of the most important functions of the stabilization group is to plan, by prediction, the complete flight program. This group will be given data on the missile's center of gravity, moments of inertias about various axes, geometrical alignment tolerances, developed thrust, firing duration, and other necessary information by the appropriate group, from which they will begin predicting the accelera-

tion, velocity, and altitude versus time curves. These predictions will become increasingly more accurate as the overall missile design features are frozen into reality.

A quarter scale wind tunnel model will be completed shortly and will be tested in the Aero School's low speed wind tunnel to gain mostly qualitative information on flight behavior.

Instrumentation

Information on what happens, or fails to happen, to the vehicle once it is in flight is very necessary for carrying out the third point of the Project's aims, namely the correlation between prediction and actuality. The determination and interpretation of this data is the job of the last of the four project groups: Instrumentation.

Plans are being made to include the signals provided by an accelerometer, an airspeed indicator, a fuel pressure indicator, the gyro and servos, and the recording camera, in the radio message transmitted to the ground from a small transmitter whose antenna is enclosed within the fins.

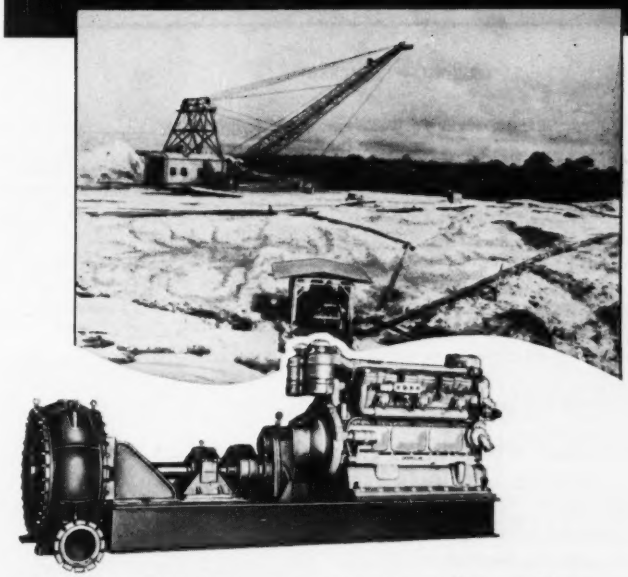
In addition, optical trackers on the ground placed at the apexes of a right triangle whose right angle marks the launching point follow the missile's flight path and either record on paper or transmit directly as a varying electrical signal to the main data center, the flight history.

The collection and correlation of all the data is an arduous task in itself, but with adequate preparation and training the instrumentation personnel will simplify this as much as possible. In addition, this group will arrange all the communication means necessary for the various tests.

Project Evaluation

Over a year's outlay of design and construction hours will culminate in a test that lasts but several minutes. Worth it? This question stands to be answered by the participants upon graduation from the University. When they take their places in the engineering and technical world they will be equipped with some of the "know-how" that can never be gained through books and blackboards alone.

Here's the most efficient dredge pump ever built . . . mining bauxite in British Guiana



MORRIS Type G Dredge Pump

"Delivers more material—in a shorter time—at lower cost." This is the one comment we consistently receive from all over the world on the Morris Type G Dredge Pump.

What makes the Type G so efficient is its design and construction—the end result of 89 years' experience in specialized pump manufacture. The patented impeller design balances casing pressure—eliminates points of unusual wear. All parts wear evenly, last far longer. Critical sections of the casing are considerably thickened to greatly increase casing life. Specially designed bearings stand up under the severest kinds of hydraulic or mechanical loads.

Because of its special bearings, the Type G can run at considerably higher speeds than normally expected of dredge pumps—and can be direct-connected to high speed Diesel engines. For example, at the Demerera Bauxite Company of British Guiana the Morris Type G shown above is driven by a Caterpillar D-386 engine through a Cotta 2 : 1 reduction gear.

Speed—output—economy . . . you get all 3 with a Morris Type G. Let our engineers help you select the right pump size for your particular needs. No charge or obligation.

MORRIS MACHINE WORKS
Baldwinsville, N. Y.
Branch Offices in Principal Cities

MORRIS Centrifugal Pumps

CORNELL SOCIETY OF ENGINEERS

107 EAST 48TH STREET 1952-53 NEW YORK 17, N. Y.

KARL J. NELSON, Ch.E. '39, *President* .....321 North Avenue East, Cranford, N. J.

THOMAS W. HOPPER, M.E. '29, *Executive Vice-Pres.*.....1700 Sansom St., Phila. 3, Pa.

WALTER M. BACON, E.E. '30.....*Recording Secretary and Secretary-Treasurer*
510 East 84th Street, New York 28, N.Y.

Philadelphia Branch
SEABURY S. GOULD, *Vice-President* .....2099 North 63rd St., Philadelphia 31, Pa.

New Jersey Branch
JOHN WEIKERT, Ch.E. '42, *Vice-President* ....714 Woodland Avenue, Westfield, N. J.

Detroit Branch
PHILIP J. KENT, M.E. '14, *Vice-President* .....P.O. Box 1919, Detroit 31, Mich.

St. Louis Branch
SHURLY R. IRISH, M.E. '18, *Vice-Pres.* ....307 South Gore Ave., Webster Groves, Mo.

Chicago Branch
WILLIAM J. MAUER, C.E. '09, *Vice-Pres.* ....503 North LaSalle St., Chicago 10, Ill.

New England Branch
HENRY GALLY, JR., C.E. '34, *Vice-President* .....14 Ingersoll Road, Wellesley, Mass.

Honorary President: S. C. Hollister, Dean of the College of Engineering

Honorary Vice Presidents:
C. R. Burrows, Director of the School of Electrical Engineering
N. A. Christensen, Director of the School of Civil Engineering
H. J. Loberg, Director of the Sibley School of Mechanical Engineering
F. H. Rhodes, Director of the School of Chemical and Metallurgical Engineering
W. R. Sears, Director of the Graduate School of Aeronautical Engineering
L. P. Smith, Director of the Department of Engineering Physics

K. J. Nelson

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."

An interesting article on reading speed caught my fancy the other day. I had suspected for a long time that my reading was a bit on the slow side. My interest aroused, I did a bit of investigating which unfortunately confirmed my suspicion. However, it appears that I have lots of company.

Authorities have found that professional people such as engineers are likely to acquire slow reading habits because much of their reading requires careful study and analysis. The word-for-word method, which is the usual result, makes all reading slow. It extends the time required to push through the never-ending pile of letters, memoranda, reports, and journals to keep informed on developments. In addition, it is conducive to brief-case toting, and it limits the amount of reading for pleasure. For this type of reading, speed with understanding is needed.

This problem is becoming more widely recognized, as indicated by the number of reading clinics which have been established throughout the country both for students and for adults. Also, there are several good books available for self-instruction. As might be expected, the results indicate that no matter how well you read, you can learn to read better. An improvement in speed of 50% with no loss of understanding is more the rule than the exception. These results are realized only through intensive practice. However, this effort should be very rewarding.

* * *

In the coming election of Alumni Trustees, it is interesting to note that three outstanding Cornell engineers have been nominated, all of whom have been endorsed by the Committee on Alumni Trustee Nominations. They are—

Leroy R. Grumman, '16
William Littlewood, '20
John P. Syme, '26

* * *

The Annual Meeting of the Society will be held in New York during the first week in May. Our speaker will be Dean Hollister. Make plans to attend this final meeting of 1952-53.

KARL J. NELSON

ALUMNI NEWS

Norman J. Gould, M. E. '99, received the 1952 Merit Award given by radio station WGVA, Geneva, from the Rev. Alexander Thompson of Geneva's North Presbyterian Church. The award, given in January, was presented to the former congressman and president of Gould's Pumps, Inc., Fall Street, Seneca Falls, because "Every worthwhile undertaking of a civic and public nature in Seneca Falls has commanded his interest."

Harold (Ep) Epstein, M.E. '11, who likes to sing "If I had the wings of an angel" and is a pretty consistent reunioner, now makes H-bomb plants. No more sewers. Address, care of Gibbs & Hill, Inc., Consulting Engineers, P.O. Box A, Aiken, S. C.

Thomas H. McKaig of Buffalo, **B.Arch. '11, C.E. '13,** should be a cinch to be on hand at the Fortieth. He has purchased the building which housed the old Forest Home Inn, remodelled it for his own office and others, and has more space available to make Ithaca a local center for Cornellians' offices to serve Central New York.

Ronald W. (Ron) Post, M.E. '11, Mountain Lakes, N. J., was appointed director of engineering, Boonton Molding Co., where he has been supervising engineer of all molded parts since 1931. Well known in the plastics industry and long interested in their applications, his innovations and engineering work have earned him a prominent position in the molded-plastics field. He has lived in Mountain Lakes over forty years, has two children, Ron., Jr. and Mrs. Richard Franks, and is a pioneer of Society of the Plastics Industry.

Loring L. Tonkin, M.E. '11, Clarksburg, W. Va., retired from active service a few months ago after 8 summers and 40 years more with Hope Natural Gas Co. He was elected president 1939, chairman 1951, which office he retains. His father, Capt. John, was a founder of the company, 1898. Son John B. is a division engineer in charge of compressor stations.

Norman J. Gould (right)

Carl W. Badenhausen, M.E.'16, '17, President of P. Ballantine & Sons, Newark, N. J., was elected a director of the Prudential Insurance Co., effective February 1, 1953.

Leroy M. Slocum, M.E. '11, is welfare agent in a State organization for his native Scottsville, owns the local hardware store, has sent 2 sons through Cornell, boasts 8 grandchildren.

Mrs. Frank G. Trau (Imogene Guion) C.E. '22, was elected a vice-president general of the national society, Daughters of the American Revolution, at the continental congress in Washington, D. C., last April. She and her husband live at 710 West Washington, Sherman, Tex.

Lawrence P. Fridley, B.Arch. '32, '33, has recently been promoted to manager of the domestic sales department of Rochester Gas & Electric Corp. He has been assistant manager. He resides at 31 Owaissa Drive, Rochester.

Sam K. Wolcott, Jr., M.E. '36, M.M.E. '45, wrote in November that in early January he would marry Nannelore Fuhr of Elmira, formerly of Berlin, Germany. He is president of Keuka Fruit Products Corp., P.O. Box 124, Penn Yan.

William R. Buxbaum, B.C.E. '43, '44, who is doing building construction with N. K. Winston Associates, writes "During our apartment house building activities, ran into **Lee Turner '42,** who is connected with Otis Elevator Co." Buxbaum's address is 390 First Avenue, New York City.

M. C. Pastorelle, Chem.E. '43, has been transferred from the Goodrich plant at Institute, West Virginia, to the Research Center of the B. F. Goodrich Company at Brechsville, Ohio.

Meredith P. Cushing, B.E.E. '44, and his wife won a prize on a recent television show, "Two For The Money." He is the son of **Albert Cushing '17** and lives at 204 Morton Street, West Springfield, Mass.

Lauri F. Laaksonen, B.M.E. '51, who is employed by Foster Wheeler Corp. of New York as a field engineer in construction department, is currently working on a Shell Oil Co. refinery at Wood River, Ill. He lives at 111 Purcell Street, Edwardsville, Ill.

Richard J. Conway, Lehigh '51, selects Manufacturing Engineering at Worthington

RICHARD CONWAY checks cutting tool with machinist before milling a pump casing.

After completing his general training which brought him in contact with all departments, Richard J. Conway decided that manufacturing engineering was his field. He says, "I chose the Manufacturing Engineering Department after completing my general training at Worthington because as a graduate in Industrial Engineering I can learn the practical aspects of my field while applying theory I learned in college.

"The personnel of this department work together as a team toward the solution of the numerous problems which arise daily. We have the cooperation of all other departments in the corporation in getting the necessary facts pertinent to the solution of these problems. In the course of our day it may be necessary for us to meet the Plant Manager, Chief Engineer, Comptroller, several department heads, clerks, foremen, machinists and many others throughout the company.

"I have contributed to the solution of many problems handled by this department including metal spraying, machining procedures, purchasing new equipment and designating proper dimensions to obtain desired fits between mating parts.

"I enjoy my work because I'm doing the work I want and my formal education is being supplemented with practical knowledge gained from the tremendous wealth of knowledge available to me at Worthington. I know from personal contact with many other departments in the Corporation that Worthington can and will find their young engineers a spot which will give them the same opportunities as have been afforded me."

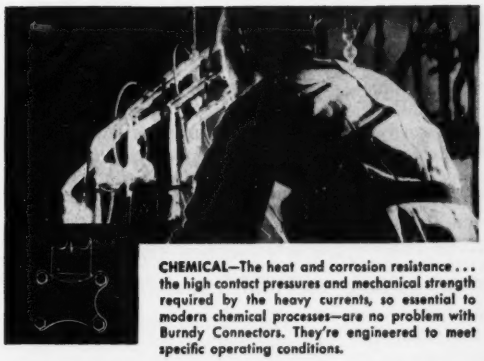
When you're thinking of a good job, think *high*—think *Worthington.*

FOR ADDITIONAL INFORMATION, see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

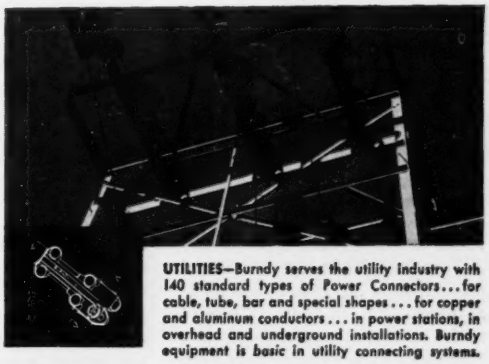
WORTHINGTON

The Sign of Value Around the World

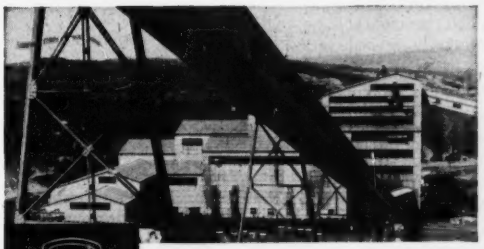
Wherever there's electricity... you'll find Burndy connectors on the job!



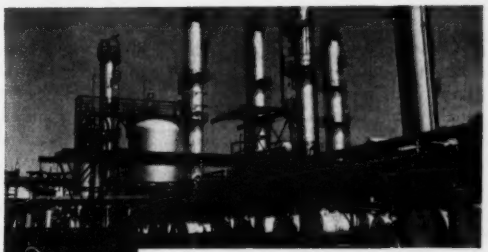
CHEMICAL—The heat and corrosion resistance... the high contact pressures and mechanical strength required by the heavy currents, so essential to modern chemical processes—are no problem with Burndy Connectors. They're engineered to meet specific operating conditions.



UTILITIES—Burndy serves the utility industry with 140 standard types of Power Connectors... for cable, tube, bar and special shapes... for copper and aluminum conductors... in power stations, in overhead and underground installations. Burndy equipment is basic in utility connecting systems.

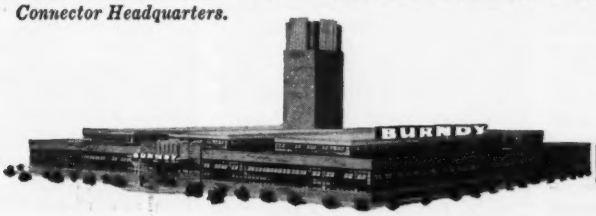


MINING—Underground heavy-duty wiring systems must be protected against dampness, vibration, dust. Where a short circuit might cut off fresh air, stop the shaft elevators, throw out the lighting, interrupt pumping, or even cause an explosion—unfailing operation of the electrical installation is literally a matter of life or death. Leading engineers specify Burndy Connectors.



PETROLEUM—Burndy Ground Connectors are used extensively in oil refineries to protect electrical installations to prevent fires and explosions that might be caused by sparks of static discharges or by lightning. Burndy Ground Connectors, of every type, are designed and manufactured as accurately as those which are called on to carry current continuously.

Burndy Connectors are specified because of their superior performance in joining, terminating, clamping, and grounding every size and functional variety of electrical conductor—from the smallest home wiring circuit to the largest industrial installations. Burndy engineering is continuously developing more and more efficient connecting methods. *Engineering graduates and students are welcome visitors at Burndy Connector Headquarters.*



BURNDY

BURNDY ENGINEERING COMPANY • NORWALK, CONNECTICUT • BURNDY CANADA LTD., TORONTO, ONT.
"WORLD'S LARGEST MANUFACTURER OF ELECTRICAL CONNECTORS"

THE DIAL TELEPHONE

By CHARLES B. MEYER, EE '56

Illustrations Courtesy Bell Telephone Laboratories

At present there are three types of dial systems used by the Bell Telephone System: step-by-step equipment, panel equipment, and crossbar equipment. The newest of these three types is the crossbar system. Inasmuch as there are three types of crossbar systems (no. 1, no. 4, and no. 5) this article will treat only the no. 5 crossbar system, which is the newest type of any dial system now in use. The initial no. 5 crossbar installation was made at Media, Pa., in 1948. It proved to be successful and since then a number of these systems have been installed.

In order to appreciate crossbar, it is advisable to examine briefly the other two dial systems so that comparisons may be drawn. The panel system is rather old and very common in metropolitan areas such as New York City. It is a partly mechanical system consisting of cords and sliders which move along vertical rods. The panel system, in my opinion, is vastly limited due to the mechanics of its construction. The step-by-step system utilizes a Strowger automatic switch. This switch has ten vertical and ten horizontal positions. In dialing a number such as EVergreen 2-1000 seven Strowger switches would be required during the entire conversation. One difficulty with each of the above systems is that a certain amount of common equipment is required for each conversation, and it is used for the entire length of the conversation. The advantage of the crossbar system is that the common equipment is used only at the beginning of each call. This permits a crossbar office of say 8000 lines to handle peak loads more efficiently than a step-by-step office of the same line capacity.

Crossbar equipment may be divided into two parts: common equipment which acts as a control, and switching frames through which talking connections are made. The switching frames consist primarily of crossbar switches (from which the system derives its name). The crossbar switch consists of 10 horizontal elements and 10 or 20 vertical elements. There are usually 20 vertical elements. Means are provided for connecting any one of the vertical elements with any one of the horizontal elements. In particular, there are two types of switching frames: the line link frame and the trunk link frame. A customer's line is terminated on a vertical element of the line link frame. This termination is located by giving, instead of the customer's phone number, his frame number, horizontal group, vertical group and vertical file of his position on the line link frame. Hence a customer's phone number would have nothing to do with his position on the line link frame. This feature allows the traffic department more freedom in assigning phone numbers, as the phone number assignments are not limited by other equipment restrictions.

The trunk link frame is somewhat similar in construction, at least, to the line link frame. No customers, however, have their lines terminated at this frame. Only intra-office trunks, inter-office trunks, trunks to certain common equipment, trunks to operators, and special purpose trunks appear on the trunk link frame. For connections between the line link frame and the trunk link frame wires designated as "junctors" are found. Once a talking connection between two customers has been established, we would find the path to be the following: the calling party's vertical element in the line link frame would be connected to one of ten horizontal elements in the line link frame. This horizontal element would eventually be connected to one end of a junctor on this frame. The other end of the junctor would be connected to a trunk on the trunk link frame. After being switched at the trunk link frame to a second junctor, the path would follow this second junctor, which terminates at the line link frame where it would be switched to the called party's line. In short the path is from customer's vertical element to junctor, to trunk, to junctor, to other customer's line. (Fig. 1)

Equipment

The common equipment consists of:

1. The markers which establish all connections. (Fig. 2)
2. The registers, which store information, such as phone numbers.
3. The senders, which transmit information to other central offices.
4. The number group frames, which translate phone numbers into equipment locations.
5. The connectors, which are multicontact relays designed to provide the leads to and from the markers.

The marker is a large group of frames containing approximately 1400 relays. It is required to perform many functions in a short time, and there are relatively few markers for each office, the maximum being 12. The no. 5 crossbar system, in order to be economically justified, must have a minimum of common equipment. This minimum is approached to some degree when the equipment operates as rapidly as possible. The markers, because of their many simultaneous functions, must be equipped with relays which have a small operate time and a large contact stack-up. This is achieved by using the "U" and "Y" series of Western Electric relays.

Let us consider some of the marker's functions. The customer lifts his receiver from its cradle

(*Continued on page* 28)

THE DU PONT DIGEST

A GROWING FIELD—

Instrumentation

Modern manufacturing trends at Du Pont bring ever-increasing opportunities for technical men

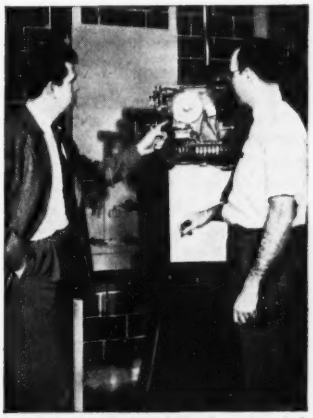
Do you think of instrumentation as applying only to work in electricity and electronics?

Or would you also include problems in chemical processing, materials of construction and materials handling, as well as application of equipment — both mechanical and hydraulic—for measurement and control systems?

At Du Pont, instrumentation is applied to widely diverse areas of manufacturing operations. It calls for many different technical backgrounds. In a typical instrument group there may be men whose formal training has been in mechanical, chemical, electrical or metallurgical engineering, or in physics, etc.

Instrumentation is becoming more and more important in the chemical industry. In fact, many of today's processes and products would not be possible without modern measurement and control systems. The trend toward continuous processes means challenging and constantly increasing opportunities for instrumentation men.

Du Pont's instrument program includes research, development, design, and supervising installation of process control equipment. Some of the work is done in the central Engineering Department at Wilmington. However, most of the major plants across the country now have their own organized instrument groups.



Fred R. Struder, *B. Metal W., Rensselaer P.I. '50, examines a pressure strain recorder with Allen R. Furbeck, E.E., Princeton '39.*

Richard G. Jackson, *B.S. in Ch.E., Columbia '42, and Gregory L. Laserson, Ph.D. in M.E., Columbia '49, test an infrared gas analyzer.*

Paul D. Kohl *(left), B.S. in M.E., Purdue '46, checks the assembly of an experimental control instrument.*

So you may visualize the scope and diversity of the work, here are examples of instrumentation recently developed and designed by Du Pont technical men:

1. A device to measure flow of approximately 30,000 lbs. per hour of gas at more than 10,000 p.s.i. To give 1.2% accuracy and be responsive to flow-changes of five cycles per second.

2. A device to monitor continuously 1200 similar temperatures. Equipment to record temperature and sound alarm at a deviation of 1°C. from desired point.

3. An automatic control system to maintain a predetermined pressure-temperature relation in a large-batch autoclave during spontaneous reaction between two chemicals.

Thus it can be seen that Du Pont instrumentation is limited to no single avenue of engineering. Men with an aptitude for the work get experience in many phases of the Company's technical activities—and an excellent background for positions in management and administration.

ASK FOR "Chemical Engineers at Du Pont." New illustrated booklet describes initial assignments, training and paths of promotion. Just send post card to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.

DU PONT

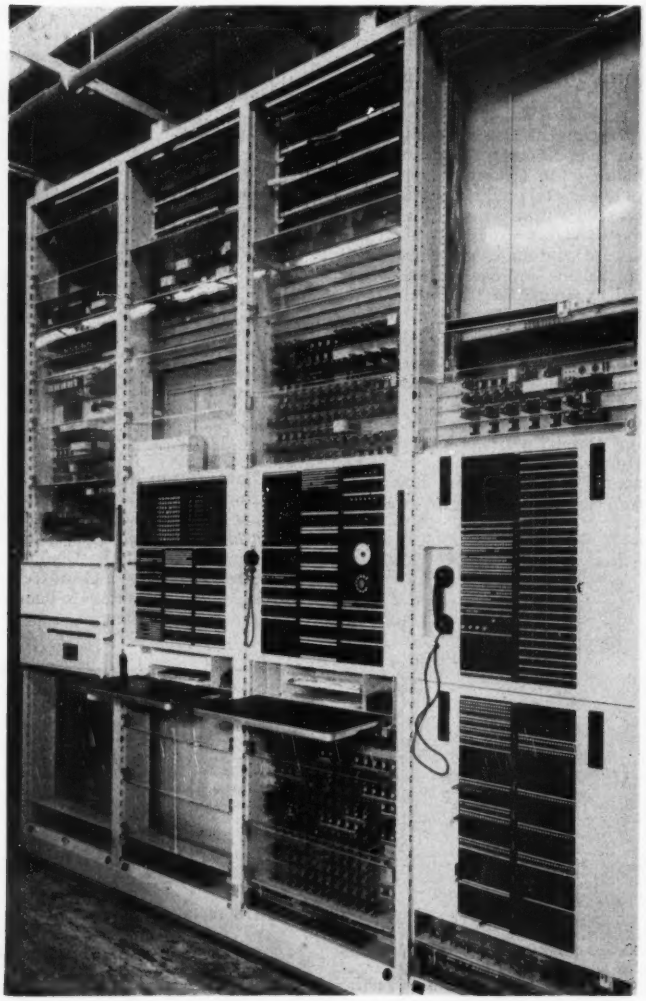
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Watch "Cavalcade of America," on Television

(*Continued from page 26*)

and the marker senses that a line is attempting to receive dial tone. The marker then locates that line by the customer's equipment location, i.e., the line link frame number, the horizontal group, the vertical group, and the vertical file. Since the originating register supplies dial tone to the customer and records the number dialed by the customer, the marker tests all originating registers for availability. (Originating registers are used for all calls originating from customers whose lines terminate in the central office.) The marker has a preference circuit which enables it to select a particular originating register from those which present themselves as being available for use. The marker now looks for a path from the trunk link frame, to which the originating registers are wired, to the particular line link frame at which the customer is located. By this time the marker has ascertained the customer's equipment location, his class of service, and whether he is a tip or ring party. As soon as a path, or "channel," as it is called, between register and customer's line has been made, the marker transmits this information and the channel number to the originating register. The originating register then supplies dial tone and the marker releases. The time required for the entire sequence of events, beginning with the removal of the receiver and terminating with the register supplying dial tone is not more than 325 milliseconds.

Master test frame used in the modern dial telephone system.



Special Features

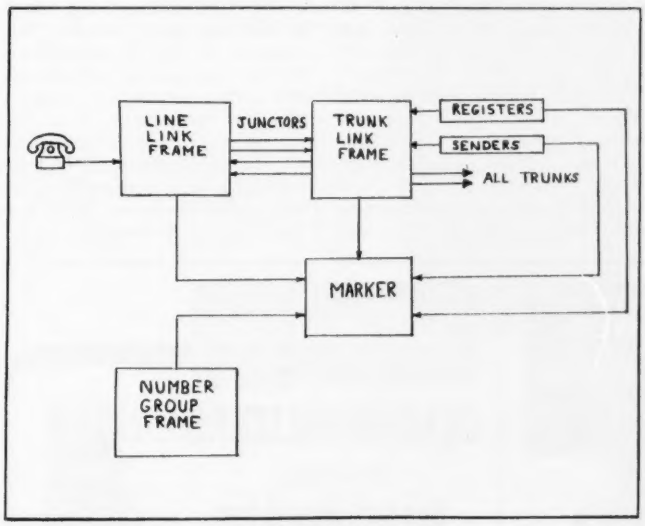
There are some special features built into the markers which give more efficient handling of calls during peak load hours. For example, if a marker finds a trouble condition which prevents it from completing a call, it will "time out" and stamp out a trouble report on a punched card. This trouble report aids the maintainer in locating the difficulty. As the first marker "times out," it calls in another marker to see if it can complete the call. If the second marker fails, it calls in a third marker, which transfers the call to an overflow signal trunk. This process of calling in a second marker is termed a "second trial feature." It is interesting to note that if the third marker is unable to transfer the call to the overflow signal trunk, the originating register (to which the calling party is connected) will give the overflow signal. The originating register does not normally give the overflow signal because it is undesirable to have it used such a relatively long time for a single call. A second, but similar feature, is found when a marker finds all trunks or junctors busy. It will "recycle" once and test them all again to see if one is available for use. If not, it will transfer the call to an overflow signal trunk. If there is no channel available to an overflow signal trunk, the originating register will give the overflow signal, as in the preceding example. These two features of the marker make the no. 5 crossbar system especially attractive in communities where there is a large number of local calls. They are not found in other telephone systems, such as step-by-step equipment.

The originating register is a storage or "memory" unit of the no. 5 crossbar system. While electrostatic and traveling wave tube storage

units have been used for computer work, the originating register is, like its big brother, the marker, an all-relay unit. Before we consider the individual function of the register, let us examine the method used for the storage of digits.

The "two-out-of-five" method can store any one of the digits 1, 2, 3 . . . 0 where the 0 stands for 10; i.e., dialing the number "0" on a telephone causes ten pulses to be sent over the line. The "two-out-of-five" method utilizes five relays labeled 0, 1, 2, 4, and 7. Any one of the ten digits is indicated by operation of exactly two relays. The digit stored is equal to the sum of the two operated relays. For example, the number 1 by the operation of relays 0 and 1, the number 5 by the operation of relays 1 and 4. 0, or "ten," as you may wish to call it, is arbitrarily designated by the operation of relays 4 and 7, since no combination of two relays yields 0. This "two-out-of-five" method is desirable inasmuch as it lends itself to a self-checking feature. All that is necessary for a check is to see that exactly two relays are operated. Similar methods are found in the markers and senders.

Shortly after a customer lifts his receiver he is connected by a marker to an originating register, which supplies the customer with dial tone. At the same time the marker tells the originating register the customer's equipment position, which the register stores. The customer then dials the number he desires. In a number such as MIdway 2-6776 each of the seven pulse trains is stored in the register by the "two-out-of-five" method. At the end of the pulses, the register transfers the information it stored to a marker, which attempts to complete the call. Unless trouble conditions arise, the work of the originating register will be finished as far as that call is concerned. All originating registers are connected to the number 2 horizontal group of switches in the trunk link frame. Since their selection is random, each should receive equal usage. The originating registers are connected only to the lines of customers whose lines terminate in the particular central office in which the originating registers are located. Calls from other central offices are routed to incoming registers, which are very similar to the originating registers. Trunks which come from other central offices are connected to incoming registers. The incoming registers are similar to the originating registers, and they serve the same general purpose, namely to store the number of the called party.



No. 5 Crossbar marker

The senders, or outgoing senders as they are more correctly termed, are used when a call which originates in a no. 5 crossbar office must be trunked to another central office. For example, a call from MIdway 2- office to the WElsh Valley 4- office would require a sender. The sender transmits the last four digits of the called number over a trunk which terminates at the called office, i.e., the WElsh Valley 4- office.

Although there are actually four different types of senders, we will describe only two: the dial pulse sender and the multifrequency sender. The dial pulse sender is used in conjunction with step-by-step offices. This type of sender transmits pulses which are essentially identical to those sent out by a customer's phone. Most phones are adjusted to transmit from 8 to 10 pulses per second. Although the dial pulse senders can be adjusted in some instances to transmit approximately 20 pulses per second, 4 ten-pulse digits would require at least 2.3 seconds for their transmission. The no. 5 crossbar system, when it is the system in use at both the office for the calling and called parties, makes use of the multifrequency sender. This sender utilizes a method which is the same in principle as the "two-out-of-five" method. Each digit is represented by the simultaneous transmission of two tones, just as in the originating register each digit is represented by the operation of two relays. In the number 4 toll crossbar system we find that more than five fundamental tones are required, because separate combinations of tones are used as start and stop signals. The multifrequency senders have a much shorter holding time than the dial pulse senders and hence are more efficient in the handling of inter-office calls. They have an ultimate capability of sending 10 digits per second. Their chief restriction is that they may be used only with crossbar equipment.

The number group frame is a device for translating a phone number into an equipment location. Since each number group frame can handle but 1,000 phone numbers, there are several frames in each office. Each frame, in addition to translating the phone number into an equipment location, gives additional information concerning the phone number in question. An example of such information would be whether or not the number is a

party line and to which side of the line ringing current should be applied. Phone numbers which are assigned to private switchboards such as would be found in an office building are termed "P.B.X. trunks." The phone numbers for these trunks are ordinarily in sequence, and if the particular number dialed by the calling party is busy, the equipment should attempt to find some other vacant trunk to the original destination, even though it is not the exact trunk corresponding to the number dialed by the calling party. This process of finding a vacant trunk when the dialed trunk is busy is termed "P.B.X. hunting." The number group frames will indicate whether or not P.B.X. hunting is required when they perform the translation from phone number to equipment location. This translation is performed by means of cross-connecting fields.

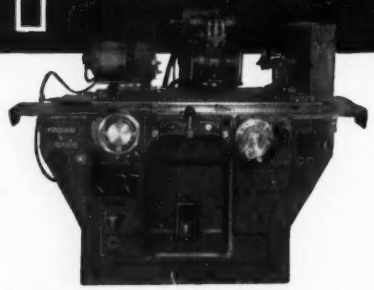
The number group frame is used in the following manner. After the register has recorded the number of the called party, a marker is called in. The marker takes the called number and feeds it to the appropriate number group frame, which translates this number into an equipment location and supplies certain other information which was described previously. The marker upon receiving this information from the number group frame handles the remainder of the call, and the number group frame is released. If a number to which no phone is assigned is dialed, the marker will receive a signal from the number group frame that there is no cross-connection in the cross-connecting fields. In this case, the marker routes the call to an intercept operator who asks the standard question, "What number were you calling, please?"

Connectors are banks of multi-contact relays which connect the necessary control and test leads to and from the markers. Those that connect leads to the markers are known as "marker connectors." Those that establish leads from the markers are termed "frame connectors." Inasmuch as they perform no other functions, we will consider them no further.

There is one other piece of equipment which, although it is not strictly speaking common equipment, is vital in the operation of the no. 5 crossbar system. It is the master test frame (Fig. 3). This frame records troubles as they happen by use of perforated cards. This frame is also the central maintenance point. If a customer accidentally leaves his receiver off the hook, a "permanent signal" lamp will flash at the rate of 120 flashes per minute. After a test has been made to determine the cause of the permanent signal, the lamp flashes at a rate of 60 flashes per minute. Any piece of equipment may be tested at this frame, and any common equipment (a marker of 1,400 relays, for example) may be removed from service by the insertion of one dummy plug.

This description of the no. 5 crossbar system is anything but complete. It is to be remembered, however, that persons working with this system are sent to a special school for eight months before they are assigned to a no. 5 crossbar office. In several places the explanations have been oversimplified, but the overall description of the system is essentially correct.

4 Completely NEW Universal Grinding Machines



"Productioneered" for new grinding flexibility and high output

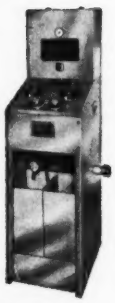
The many exclusive features of the new, ultra-modern Brown & Sharpe Universal Grinding Machines provide exceptional grinding flexibility, rigidity, and accuracy. Instant combining of operating functions into automatic cycles extends the usefulness of this equipment beyond the toolroom and job shop to many production applications. Four sizes: No. 1 (illustrated), and Nos. 2, 3 and 4.

Write for detailed Bulletins. Brown & Sharpe Mfg. Co., Providence 1, R.I., U.S.A.

Brown & Sharpe BS

Barnstead

DEMINERALIZERS *Provide* High-test, Mineral-free WATER



FOR ONLY 5c *Per Thousand Gallons*

Barnstead Demineralizers increase production, reduce rejects, and insure better product control. Barnstead Demineralizers produce high-test, mineral-free water for as little as 5c per 1000 gallons, with a minimum of supervision and maintenance.

Write Today for Literature

B 75 Years of Progress in Pure Water 1878 1953

Barnstead STILL & STERILIZER CO.

45 Lanesville Terrace
Forest Hills
Boston 31, Mass.

A MESSAGE TO
COLLEGE ENGINEERING
STUDENTS

from A. C. Monteith, Vice President
in Charge of Engineering and Research,
Westinghouse Electric Corporation

There's room to grow at Westinghouse

It's natural that you sometimes wonder about the "elbow room" in the field of engineering. Even though the past half century has witnessed great technological developments, they are only a prelude to the things to come. We have barely scratched the surface in the fields of engineering development and research. And that, most certainly for you, should mean there *is* room to grow.

But first you must find the right starting point—a company which will give you the opportunity you want in your career. Westinghouse offers you this kind of opportunity, for it is a growing company in a dynamic field. Energy is our business. Here at Westinghouse, well planned orientation and training, continued education. position rotation, and management development are al offered to provide you a favorable climate in whicl. to grow.

To those who are prepared and willing—whether inclined toward research, engineering, manufacturing or sales—opportunities with Westinghouse are limitless.

G-10252

For information on career opportunities at Westinghouse, consult Placement Officer of your University, or, send for our 34-page book, *Finding Your Place in Industry.*

Write:
Mr. C. S. Purnell
District Educational Co-ordinator
Westinghouse Electric Corporation
40 Wall Street
New York 5, New York

YOU CAN BE SURE...IF IT'S
Westinghouse

NEWS OF THE COLLEGE

AIChE

The student branch of the American Institute of Chemical Engineers made a field trip to the Great Western Winery at Hammondsport, N. Y., March 19. An inspection tour was followed by sampling of the company's product. On March 20, the AIChE heard a talk by Mr. Blackwood of the Esso Company on "Evaluation of fuels for internal combusion engines."

MetESoc

The Society of Metallurgical Engineers will sponsor a film on "Principles of Corrosion" to be shown April 10 in Olin Hall Lecture Room M. This sound and color film has been five years in the making by International Nickel Company. All engineers are invited to attend this meeting.

ASCE Convention

The Cornell Chapter of the American Society of Civil Engineers will be host to the upstate New York Regional Conference convention chapters, April 17th and 18th. The member schools of the Conference include Cornell, Clarkson, R.P.I., Syracuse, and Union.

The planning committee, under the chairmanship of Clifford Evans, CE '54, has been working to arrange an interesting, pleasurable convention. The convention centers around a competition among the various attending schools for the best student paper submitted. The best paper from each school will be read before the convention, with a cash prize for the winner.

In addition to student papers, an extensive social program has been arranged. Friday, April 17th, there will be a dance at the Ithaca Hotel, and on Saturday the 18th there will be a banquet at Willard Straight Hall. The committee has invited all engineers to attend the Ithaca Hotel dance.

Dr. Theodore Van Karman, renowned aerodynamicist who gave Messenger Lectures at Cornell during March.

Engineers Day

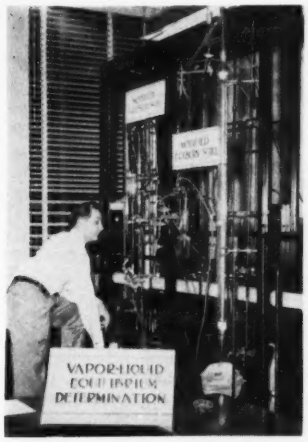
Want to know what goes on behind the walls of Sibley, Franklin, White, Lincoln, Rockefeller and Olin Halls? For the fifth consecutive year the Cornell campus and the general public will be treated to a glimpse of the experimental and practical phases in all fields of engineering when the College of Engineering holds its annual E-Day open-house. Friday, April 24, is the date when students in the six engineering schools will exhibit and explain the intricacies of projects in their respective fields to their E-Day guests.

Sponsored by the Cornell Student Engineering Council, this year's displays promise to be more entertaining and spectacular than any previous program. As has been the custom, the annual open-house will be held in conjunction with Cornell Day when over two hundred sub-frosh from eastern high schools will visit the campus for a first-hand view of college life.

Work is progressing on a combined program which is designed to show visitors just what the students and faculty are doing within the confines of the College of Engineering. In addition to those standard exhibits and demonstrations which are being repeated by virtue of their popularity during previous years, many new projects will be on display. The College of Architecture will feature a February graduate thesis on "A Work Community for Israel." Electrical engineers will explain the intricacies of the newest wonder in the field of electronics — the transitor. Included in the ME exhibits will be demonstrations in photo-elasticity and the testing of high-strength alloys at high temperatures—both in the new engineering materials building, Thurston Hall. The School of Engineering Physics will have on display its electron microscope, while CE's will again display their large earth-moving machines. Chemical engineers will be on hand to explain the workings of their three-story unit operations laboratory.

The administrative duties for E-Day will be handled by Bob Fowler, EE '54. School chairmen are: Charlie Soumas, EE; Roger Classey, ME; Doug McIlroy, EP; Dick Chafant, Arch; Tom Weber,

ChemE; and Crawford Greene, CE. Tom Settle, EE '54, is in charge of publicity.



Vapor-liquid equilibrium determination demonstrated in Olin Hall last year by the students and faculty of the School of Chemical Engineering.

As a climax to the E-Day weekend, the annual Engineers' Banquet will be held Sunday evening, April 26. Prof. W. H. Erickson, EE faculty member, will be the featured speaker. Presentation of E-Day awards will be made with announcement of awards given by several engineering honorary societies.

The CORNELL ENGINEER, on behalf of the C.S.E.C., wishes to extend a cordial invitation to all its readers to visit Cornell on the weekend of April 24 for the E-Day activities. The exhibits will be open from 7:00 to 11:00 p.m. on Friday night.

Visiting Architect

Daniel U. Kiley of Charlotte, Vt., was visiting critic in the College of Architecture during the month of March. Mr. Kiley, an unusual combination of architect, landscape architect and site planner, has had extensive experience since 1932. His consulting practice has covered 26 states as well as Canada and India, and has included such competitive successes as the Jefferson Memorial Competition with Eero Saarinen, the New Hampshire University Student Memorial Union Building with Ronald Gurley and the Memorial for Mahatma Ghandi with Meyer, Whittlesey, and Noguchi.

His experience as a Captain in the United States Army included positions as design chief in the Office of Strategic Services, site planner with Charles Goodman for the International Airport, and architect of the Nurnberg Court and other facilities for the International Trials.

At present he is associated with Pietro Belluschi in the design of a large shopping center near Baltimore.

Photogrammetry

Some uses of computing machines in photogrammetry were discussed by John V. Sharp, technical engineer for International Business Machine Corp., in a talk at Cornell, Feb. 24.

The illustrated talk on "Looking to the Future in Photogrammetry" was sponsored by the Ithaca section of the American Society of Civil Engineers. Members of the Cornell student chapter of ASCE and the general public attended. Mr. Sharp discussed various types of computing machines and told how they can solve civil engineering and other engineering problems.

The electron microscope which will be on display in Rockefeller Hall during E-Day on the weekend of April 24.

In 1950 the American Society of Photogrammetry gave Mr. Sharp its highest award for his work in developing an autofocus rectifyprinter. He is now a director of that society and is helping to develop new instruments for IBM.

Letters To The Editor

To the Editor:

Being of the cloth, my fancy was taken by your November Brain Teaser. With a great deal of effort I came up with the solution and was happy to note that Smith turned out to be the general.

HOWARD M. SMITH, B.Chem.E. '51
2/Lt., USAF, Cocoa Beach, Fla.

Editor's Note: Lt. Smith submitted the first seemingly correct answer with 46 steps to his proof.

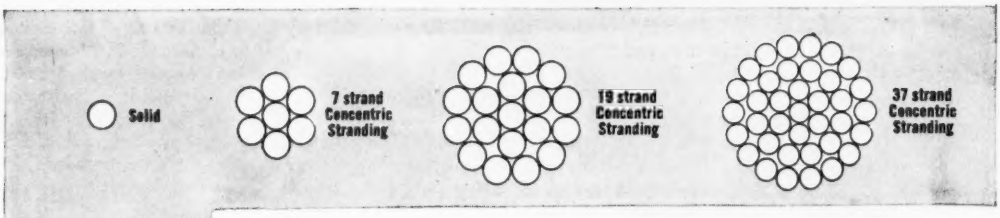
This solution supported by Mr. Claude Wall in the March issus, receives a majority vote of three out of four correspondents.

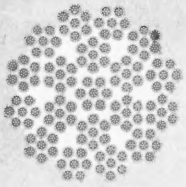
To the Editor:

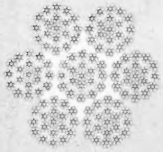
Can't buy the solution offered by EP in the January issue.

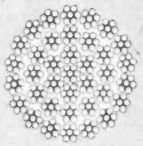
With Green a colonel and Brown a captain, poor shavetail Jones would not be on anyone's Morning Report. Have them trade ranks and he rates a tour in Japan.

J. W. MENGEL, B.Chem.E. '49
Rochester, N. Y.




19 x 7 x 19 Rope-Lay Bunched


7 x 19 x 7 Rope-Lay Bunched


37 x 7 Rope-Lay Concentric

19 x 7 Rope-Lay Concentric

7 x 7 Rope-Lay Concentric

No. 2 in a series

The Importance of Electrical Conductors

In the ability to transmit electricity, all forms of matter may be divided into two general classes, namely, conductors and insulators. Conductors permit electric current to flow readily; that is, they offer little resistance to its flow, whereas, insulators offer relatively great resistance to the flow of electricity. All substances at normal temperatures offer some resistance to the flow of electric current. In general, the metals are good conductors, while glass, oil and most organic substances are classed as insulators. Although silver offers the lowest resistance to the flow of electricity of the common metals, its cost is such that it is not widely used as a conductor. The conductors most generally used in the cable industry are made of copper or aluminum.

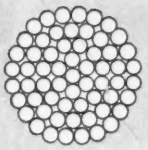
The manner in which electricity flows through elementary material may be readily visualized from the modern concepts of the structure of matter. According to these concepts all elements are made up of minute indivisible particles called atoms. These in turn are composed of a positively charged nucleus around which one or more very small negatively charged particles, called electrons, rotate at high velocity. In conductors, some of these electrons are free to move when only a small difference of potential is applied to the ends of the conductor and, since they are negatively charged, they flow to the positively charged end. This movement of electrons is electric current.

In passing through conductors, *the electrons must pass through the electron fields of many atoms. They thus collide with the atomic nuclei and other electrons. These collisions obstruct the flow of electrons and result in electrical resistance.*

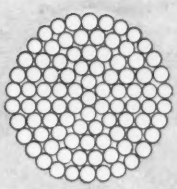
The resistance of a homogeneous conductor of uniform cross-sectional area varies directly as its length and inversely as its cross-section, the length being in the direction of current flow. That is, $R = \rho L/A$ where, R is the resistance in ohms, L is the length in the direction of current flow, A is the area perpendicular to the length and ρ is a constant of the particular material known as its specific resistivity. When the length and area are expressed in the same units such as L = one inch and A = one square inch, $R = \rho \times 1/1$ or $R = \rho$, the specific resistance of the material in ohms per inch cube.

The length and area of a conductor are generally expressed in other units than inches. The most commonly used unit of cross-sectional area used in the cable industry is the circular mil, usually designated as cir. mil or CM. This

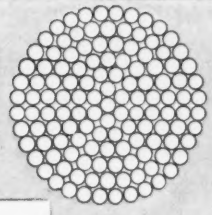
UNITED STATES RUBBER COMPANY



61 strand Concentric Stranding



91 strand Concentric Stranding



127 strand Concentric Stranding

is the area of a circle whose diameter is one mil, 0.001 inch. The area of a circular mil is $\pi/4$ or 0.7854 of a square mil. The unit of length usually associated with this unit is the foot and the resistance becomes ohms per CM-foot. The resistance of annealed copper and aluminum per circular mil-foot at 20C are 10.371 and 17.011 ohms respectively. The resistance of a copper conductor 64 mils in diameter and one foot long thus becomes $10.371 \div 64^2$ or 0.00253 ohms.

The sizes of electrical conductors *are expressed in the United States in terms of the American Wire Gauge. This was originally set up on the basis of a geometrical progression of 39 steps or sizes between a wire 460 mils in diameter (Size 4/0) and a wire 5 mils in diameter (Size 36). The ratio of the diameter of a wire to that of the next larger size in this series is 39* $\sqrt{460/5}$*=1.12293. This ratio has since been used to extend the American Wire Gauge (AWG) to sizes smaller than 36 AWG (5 mils). The sizes of conductors larger than 4/0 are expressed in circular mil area. The size of a conductor made up of a number of wires is determined from the sum of the circular mil areas of the individual wires.*

When current flows through a conductor there is, according to Ohm's law, a voltage drop of $E = IR$, where E is in volts, I is in amperes and R is in ohms along the conductor and power equal to EI watts is converted to heat. Since $E=IR$, this power converted to heat becomes I^2R watts. These two factors, voltage drop and conductor heating, are of prime importance in the design of conductors. Conductors must be sufficiently large in cross-sectional area, that is, must have sufficient low resistance that the voltage drop does not become excessive. In good design this voltage drop should not exceed 3 per cent for power circuits or 1 per cent for lighting circuits. The conductors should also be large enough that their temperature does not exceed that for which their insulation is designed. This is referred to as the current carrying capacity of conductors. The current carrying capacities of the various sizes of conductors, conductor insulations and installation conditions have been established. It should be noted that the temperature attained by a conductor depends not only on the amount of heat generated but also on the thermal resistance of its surroundings.

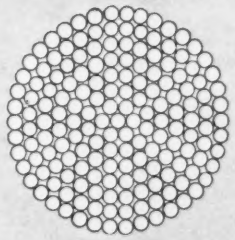
In addition to providing satisfactory voltage drop and current carrying capacity, conductors must be designed to provide adequate flexibility during installation and service. This is accomplished by building up the conductor from one or more adequately small wires depending on the flexibility required. For example, the conductor for heater cord or welding cable which is subject to repeated flexing in service is usually made up of copper strands having a diameter of .005" or .0063" while the conductor for overhead weatherproof cable may be a single wire.

For reprints of these pages write to address below.

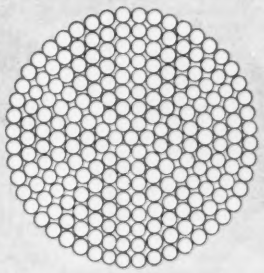
U.S.RUBBER
SERVING THROUGH SCIENCE

Electrical Wire and Cable Department

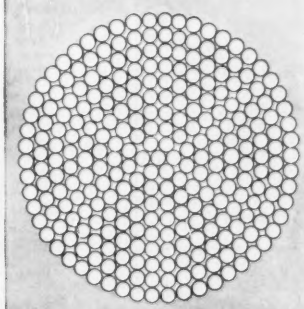
Rockefeller Center • New York 20, N. Y.



169 strand Concentric Stranding



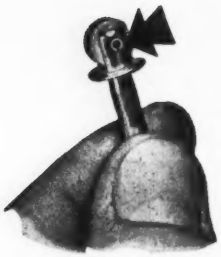
217 strand Concentric Stranding



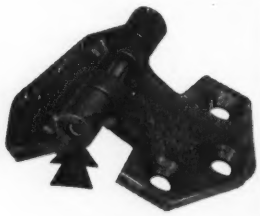
271 strand Concentric Stranding

Rope Stranding

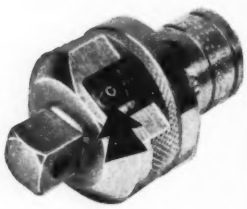
Bunched Stranding



Replacing a rivet

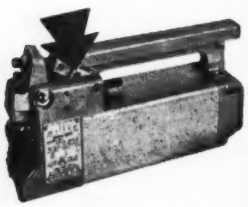


. . . a hinge pin



. . . a stop pin

. . . a set screw



. . . a bolt and nut

. . . a modern fastener that saves time and money on thousands of applications

Rollpin is a hollow, split, cylindrically formed pin with chamfered ends. It is simply driven into holes drilled to normal production tolerances. Because Rollpin is slightly larger than standard sized holes, it compresses as inserted. It is self-locking—and vibration-proof—because of the constant pressure it exerts against hole walls. Its shear strength exceeds that of a cold rolled pin of the same diameter. Rollpin is readily removed with a drift or pin punch—and can be reused.

Because of its versatility—and the production economies it makes possible—Rollpin is finding wide usage in almost every phase of manufacturing activity. Write for design information on the Rollpin. It will enable you to cut costs for many applications where use of rivets, set screws, dowels, and straight, serrated or cotter type pins create installation or performance problems.

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, New Jersey

Elastic Stop Nuts with the famous red collar are another ESNA product

Radar Prevention of Air Collisions

By JAMES Q. BRANTLEY, Ph.D. '51

Public acceptance of air travel as a safe and economical means of transportation has resulted in a meteoric growth of the commerical airlines. Passenger travel by scheduled domestic operations has increased from 1.4 billion passenger miles in 1942 to 12.3 billion passenger miles in 1952. Gross intake has more than doubled since 1947. Unfortunately air navigation and control facilities have not kept pace with the increasing density of air traffic. While old-fashioned radio ranges are being replaced by modern omni-ranges, traffic control facilities still fall short of the actual need. The combination of these factors has resulted in a severe air-to-air collision problem. Although fatalities resulting from air-to-air collisions have been relatively few (5% of the total since 1938) a single collision between two heavily loaded four-engine air transports would raise this figure to major proportions.

As an example of what can happen: On November 17, 1951, a collision occurred between two Douglas DC-4's engaged in training flights. Although only one of the planes crashed, killing its three crew members, the accident could have been a major catastrophe had the planes been carrying passengers. Another collision, this time a much more disastrous one, occurred in Washington, D.C., in 1949. This one involved a heavily loaded DC-4 and a P-38 both on final approach to the same runway. In this accident, the P-38 contacted the DC-4 just aft of the passenger cabin, its propellers completely severing the tail section of the larger aircraft. Fifty-five people lost their lives.

A partial insight into the mechanism of collision prevention can be obtained by examining the procedure used by an automobile driver to avoid collisions. Potential collisions are recognized and avoided by observing the present position of an approaching automobile; estimating its motion relative to the observer; and from this knowledge estimating the future relative position of the approaching vehicle. If the approaching car's estimated future position corresponds to the observer's estimated future position a collision is impending, in which event the driver subconsciously chooses an escape route and takes immediate evasive action. The three general phases of the procedure are: 1) acquisition of information; 2) evaluation of information obtained; and 3) evasion.

Extrapolating and expanding this procedure to aircraft use, the requirements for a self-sufficient collision warning system are as follows:

a) It must procure information sufficient for the recognition of collision threats. To do this, it must determine the target's* range, closure rate, closure angle, and rate of change of closure angle. In most cases the eye would be sufficient in this respect were it not for limitations posed by its inability to penetrate clouds and darkness.

b) The system must evaluate the data obtained in such a way that near misses or collisions can be recognized in advance. Since for aircraft this is a complex operation, some form of automatic computer must be supplied.

c) The system must warn the pilot without ambiguity so that the approximate preventive maneuver will be obvious.

Actual Case

In a practical case it is necessary to deal with more than one threatening aircraft. To do this the warning system must be capable of evaluating the collision potentials of several targets and must pick out the one offering the greatest threat. This can be done by computing the

*The word "target" as used in this discussion refers to an approaching aircraft.

ABOUT MR. BRANTLEY

James Q. Brantley Jr., an employee of Cornell Aeronautical Laboratory, Inc., received his bachelor's degree in Electrical Engineering at the University of Florida in 1949. He then came to Cornell, where he received his Master's and PhD. From 1949 to 1951, while working for his degrees, Mr. Brantley was a holder of a Cornell Aeronautical Laboratory fellowship, and during this time carried out research in conjunction with the Laboratory on the problem of in-flight collision. A graduate also of the Navy's Aviation Radio Technical program, Mr. Brantley was an instructor at the Navy's Aviation Electronics Training Center at Corpus Christi, Texas. He is a member of the Institute of Aeronautical Sciences and the Institute of Radio Engineers.

closure time of all approaching aircraft. Closure time is defined as the length of time it would take two aircraft to collide if their closure rate were to remain constant. Numerically, it is range divided by closure rate. In Figure 1 is shown an example of how closure time might be used to determine the more dangerous of two approaching aircraft. In this case aircraft A will collide with C in twelve seconds; closure time is twelve seconds. Also, if aircraft A is neglected, planes B and C will collide in 36 seconds. Note here that while A is farthest from C, it is still the more dangerous. Closure time is therefore a more meaningful yardstick for target discrimination than is range.

Shortly after World War II American Airlines conducted extensive tests of the AN/APS-10 airborne radar to determine the usefulness of radar in airlines operations. It was concluded that: the radar was very useful for in-flight weather surveillance making possible circumnavigation of dangerous weather; the radar was useful for terrain avoidance if a pencil-beam antenna pattern was used; the radar was of marginal value for blind navigation purposes; and, the radar was of little use for the prevention of mid-air collisions.

Pulse Radar

Pulse radar is inadequate for air-to-air collision warning for the following reasons:

a) Aircraft echoes are not usually strong enough to be arresting when presented on the screen of a cathode-ray tube. Especially at low altitudes where ground echoes are strong, aircraft echoes are masked by ground clutter.

b) Use of the cathode-ray tube for indication necessitates continuous surveillance of the screen by the pilot. This imposes an additional work load which is neither desirable nor practical.

c) Even if a target were noticed on the radar screen only its present position would be shown. The radar would tell the pilot where the aircraft is now, but not where it is going.

These three disadvantages combine to effectively negate the usefulness of pulse-type radars for air-to-air collision warning purposes.

The Cornell Aeronautical Laboratory, Inc., in conjunction with Cornell University, has conducted a study of the collision problem in which emphasis was placed on the applicability of continuous wave radar techniques. Continuous wave radar, while not as familiar as pulse radar, has characteristics which make it attractive for the collision warning task.

As its name implies, cw radar transmits energy continuously. Pulse systems emit energy in bursts. Both, however, measure a target's range by determining the time required for the energy to travel to a target and return. Transit time is measured using a process whereby the radar carrier-wave is marked in a characteristic way. The length of time it takes for a given mark to make the round trip between radar and target constitutes the transit time. With pulse radar these marks are pulses and are a form of amplitude modulation. With cw radar the carrier is marked by frequency modulation techniques.

The two ranging techniques can be compared by reference to the hypothetical situation where an observer has at his disposal a long distance runner who is known to average one-fifth mile per minute. If the observer sends the runner out with instructions to run to a given objective and return, by measuring the length of time between departure and arrival, distance to the objective can be determined. For instance, an elapsed time of ten minutes implies that the distance to the objective is one mile. This method is analogous to the way range is measured by pulse techniques. Suppose now that the observer had an unlimited supply of identical (clothing, appearance, speed, etc.) long distance runners. If he were to dispatch them in a steady procession toward a given objective he would have a continuous stream of runners leaving the observation position and a continuous stream returning. But since all of the runners look alike he would not be able to make a time delay measure. However, if he places a red hat on one of the runners, measures the length of time it takes the hat to go to the target and return, the delay time could be measured. This example is analogous to methods used for continuous wave ranging.

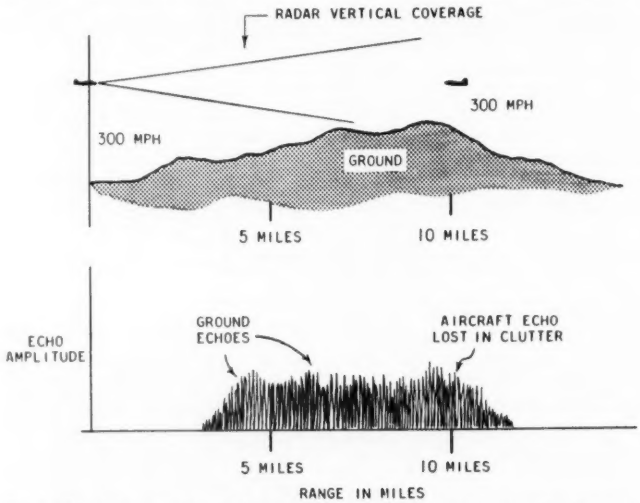


Fig. 2. **"Search by range" method employed by most pulse radars. Aircraft echoes are *smothered by ground clutter.***

One of the principal attributes of cw radar insofar as collision warning is concerned results from the fact that a target's closure rate can be measured by utilizing the doppler effect. Radar signals reflected from moving targets experience an apparent frequency shift propor-

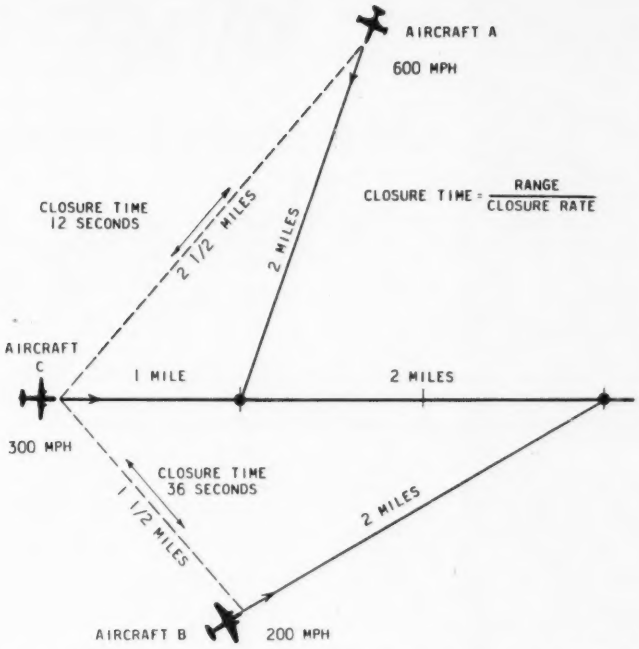


Fig. 1. Hypothetical case of "double" collision threat demonstrating that the closest plane is not necessarily the most dangerous.

tional to the target's closure rate. Measurement of this so-called "doppler shift" provides a convenient and accurate means for closure rate determination. However, because the frequency differences to be measured are exceedingly small, it is necessary that an accurate reference signal be provided. In a cw system the reference signal is inherently available from the transmitter itself, while in pulse systems such a reference is difficult to supply because the transmitter is off most of the time. Rate measurements, important for collision recognition, are therefore more conveniently made using cw radar techniques.

A radar system's maximum range capabilities at low altitudes are enhanced by an ability to search by closure rate rather than by range. Figures 2 and 3 illustrate how a "search by closure rate" system is superior to a "search by range" system for detecting moving targets. In Figure 2, it can be seen that echoes are received from the ground over a wide span of ranges. Hence, ground echoes tend to mask reflections from the approaching aircraft. In Figure 3, however, ground echoes are clustered about the radar-carrying aircraft's ground speed of 300 miles an hour, and the target's closure rate of 600 miles an hour places its echo beyond the ground echoes. Effective elimination of ground clutter in this way permits detection of aircraft at ranges exceeding those achievable with ordinary search by range systems. For closure rates which place aircraft echoes down in the ground clutter (Figure 3) a loss in maximum range results. This is not serious, however, since for lower approach rates early detection is not as important as for higher rates. For high-speed targets, such as that shown in the illustration, the search by closure rate method is at its best.

The most common way of determining closure angle is with the use of directional antenna systems. Such systems are complex if large regions are to be searched and complications result from airframe space limitations. Further, if high angular resolution is desired, antenna physical dimensions are large. For these reasons, measurement of closure angles will be restricted to rough approximations. Rather than finding application in recognizing a collision condition, closure angle would be used primarily for determining the appropriate turn direction for avoidance of an impending collision. With improved techniques of angle measurement, the constant angle collision criterion may be utilized in the design.

It was mentioned earlier that the data evaluation function of collision recognition is complex and will require some form of computer. A collision warning computer would

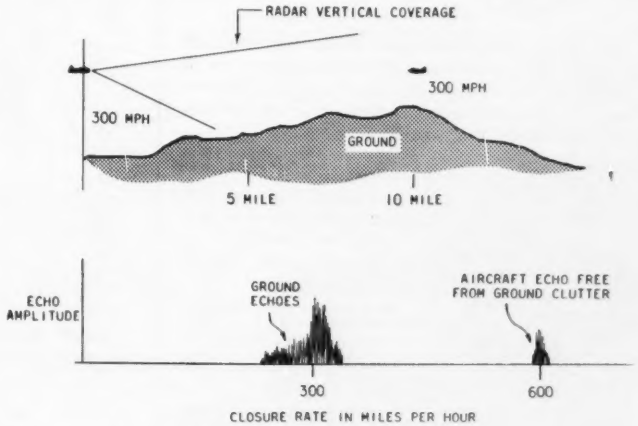


Fig. 3. "Search by closure rate" method employed by continuous wave radar. Echoes from high-speed aircraft are not masked by ground clutter.

perform the following functions: it would compute closure times for all targets detected by the radar; it would choose the target demonstrating the lowest closure time and would measure precisely that target's closure rate and, if technically feasible, rate of change of closure angle; should the target demonstrate a constant rate and/or angle the computer would actuate an appropriate indicator; in the event of a collision threat, the computer would actuate the pilot's indicator in such a way that the necessary evasive action would be apparent; and the computer would note the effects of evasive actions and would inform the pilot as to the effectiveness of his maneuvers. The principal circuits needed for the computing functions were constructed at C.A.L. and Cornell University and were subsequently evaluated. As a result of this work it is felt that implementation of an appropriate computing device would offer no insurmountable obstacles. The biggest difficulties result from the application's severe requirements of accuracy and reliability. It is felt, however, that these requirements can be met.

Ground tests of a continuous wave radar, the AN/APG-17, were made at the Buffalo Airport during the summer of 1951. The AN/APG-17 is a 1500 megacycle radar employing a broad-beam antenna system (66° in azimuth and 74° in elevation) and having an average transmitter output power of only 1 watt. Operating this equipment without frequency modulation, transport type aircraft were detected at ranges up to 2½ miles. Smaller private aircraft were consistently detected at ranges approximating one mile. These figures were obtained under ideal conditions of no vibration and no supply voltage variations. In an airborne installation, these ranges would be appreciably reduced, but the loss could be regained by increasing transmitter power and antenna gain. Results indicate that adequate ranges, in the neighborhood of 6 miles, are achievable.

There are those who believe that the collision hazard could be eliminated if a perfect navigation system were developed and put into service. Objections to this approach are three: 1) there is no such thing as a perfect navigation system; 2) even if there were a perfect system, private flyers probably could not afford the necessary equipment and would offer collision threats to commercial aircraft; and 3) in all probability the navigation system would depend on land—based equipment and would not be effective for overseas flights. Admittedly the probability that a mid-air collision will happen in over-water operations is small, but should one occur it must be agreed that it would be spectacularly destructive.

In view of these considerations, it may be reasonable to assume that a self-sufficient system, such as that which has been hypothesized, is of the type which could provide the ultimate and adequate solution. Assumptions, however, are not sufficient and only thorough testing and operational experience can provide a definite conclusion.

The Glenn L. Martin Company, builders of "Matador" bombers, "404" transports, and other famous planes, uses 27 Frick compressors for air conditioning and special cooling services in its great plant at Middle River, Md. These machines have been installed over a period of 16 years by the Paul J. Vincent Co., Frick Distributors in Baltimore.

Frick "ECLIPSE" Compressors Handle Air Conditioning Work with Extra Economy: ask for details.

For dependability and convenience, specify Frick air conditioning, refrigerating, ice making and quick freezing equipment.

For a position with a future inquire about the Frick Graduate Training Course in Refrigeration and Air Conditioning. Operated over 30 years, it offers a career in a growing industry.

FRICK CO.
WAYNESBORO, PENNA. U.S.A.
Also Builders of Power Farming and Sawmill Machinery

Out on the job . . . irrespective of your engineering role . . . you'll be coming to grips with the problem of eliminating wasteful friction.

You can look to SKF for the practical solution to anti-friction bearing problems.

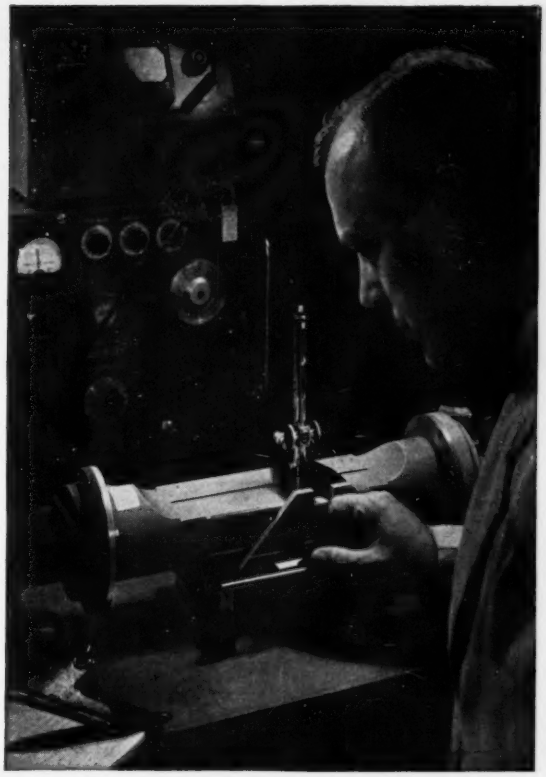
SKF makes all of these eight types of bearings which serve virtually every equipment need. Rely on SKF for *putting the right bearing in the right place.* 2617

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of **SKF** *and* HESS-BRIGHT *bearings.*

SKF
BALL AND ROLLER BEARINGS

Build your future with Bendix

AVIATION CORPORATION



JOIN AMERICA'S LEADING TEAM OF CREATIVE ENGINEERS!

Your opportunity is as big as you want to make it in Mechanical Engineering • Hydraulic Mechanisms • Electronics • Magnetics • Computers • Servo-mechanisms • Radar Research • Metallurgy • Solid-State Physics • Instrumentation • Radiation Detection • Nuclear Physics • Guidance and Control Systems plus many more engineering fields.

You'll find Bendix has much to offer the young graduate engineer of today. It's only natural since the Bendix Aviation Corporation is primarily a *creative engineering* and manufacturing organization—unlike any other in America in its versatility, facilities, experience and range of products. And of real importance to you is the fact that this firm is engineering-minded from top management down. Currently, Bendix engineers—an average of 1 out of 18 employees as compared to the all-industry average of 1 out of 50 employees—are building important careers for themselves in design, development, research, production supervision and sales. Many of these men come from schools such as yours. Whatever engineering field you've trained for, and wherever your interests lie in that field, you'll find positions at Bendix that provide the answer you've been looking for. Plan now to build your future with Bendix!

BENDIX AVIATION CORPORATION
Executive Offices: Fisher Building, Detroit 2, Michigan
DIVISIONS, PRINCIPAL SUBSIDIARIES AND AFFILIATED COMPANIES

Bendix Products Division, South Bend, Indiana
Hamilton Division, Hamilton, Ohio
Bendix Radio Division, Towson, Maryland
Eclipse-Pioneer Division, Teterboro, New Jersey
Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio
Utica Division, Utica, New York
Bendix Computer Division, Hawthorne, California
Eclipse Machine Division, Elmira, New York
Friez Instrument Division, Towson, Maryland
Marshall-Eclipse Division, Troy, New York
Pacific Division, North Hollywood, California
Red Bank Division, Red Bank, New Jersey
Skinner Purifiers Division, Detroit, Michigan
Cincinnati Division, Cincinnati, Ohio
Scintilla Magneto Division, Sidney, New York
Zenith Carburetor Division, Detroit, Michigan
Kansas City Division, Kansas City, Missouri
York Division, York, Pennsylvania
Bendix Aviation Research Laboratories, Detroit, Michigan
Pioneer-Central Division, Davenport, Iowa

Nation-wide Network of Plants and Laboratories Enables You to Choose Your Location

Bendix operations and activities are distributed among 13 laboratories and 22 manufacturing centers. Each functions independently with its own engineering staff. As a result, you enjoy a small company atmosphere but benefit from the facilities of a large organization. Last year, Bendix spent over $50,000,000 for engineering alone. For sure, ideas are not cramped at Bendix!

For complete information on a Bendix engineering career, have your placement office arrange an interview for you with the Bendix Representative who will be at your campus soon. Or write to:

Bendix
AVIATION CORPORATION
FISHER BUILDING
DETROIT 2, MICHIGAN

Bendix Products Are Used in These Industries and Services

Agriculture, Automotive, Aviation, Electronics, Atomic Energy, Lumber, Marine, Metals, Petroleum, Public Service, Railroad, Textile, Construction

PHOTO EN

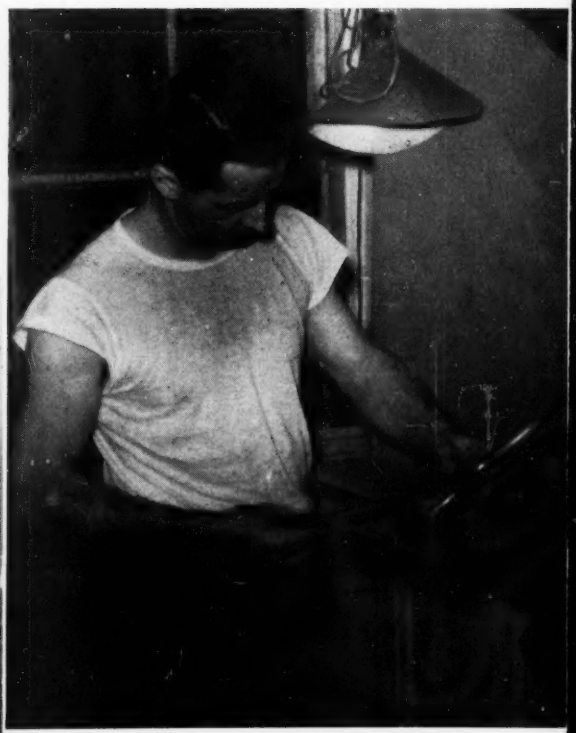
Above: Franklin Hurtt of the Art Department retouching a photograph.

Photoengraving, the process of reproducing a photograph or drawing on a metal plate, to be reproduced again in a magazine or newspaper, is a complicated and highly technical art. Ithaca Engraving Company is Ithaca's only photoengraving firm. All the pictures presented on these two pages were taken there. Books have been written just on this process; thus its description below is merely a brief outline.

The photograph or drawing to be used is first photocopied down to its final size, using special fine grained, high-resolving-power stripping film. For a picture to have a full range of greys, instead of only black and white sections, the grey part must be composed of minute dots; the larger the dots, the darker the grey. To achieve this a screen is superimposed upon the picture, breaking down the copy into component dots.

A magazine, such as the CORNELL ENGINEER, will use a screen with one hundred or one hundred twenty dots to the inch. The negative is then glued to glass. At this point several negatives can be cut to shape and fitted together to form a composite. The glass negative

Right: Bill Dolkos of the etching department preparing a plate for a nitric acid bath.



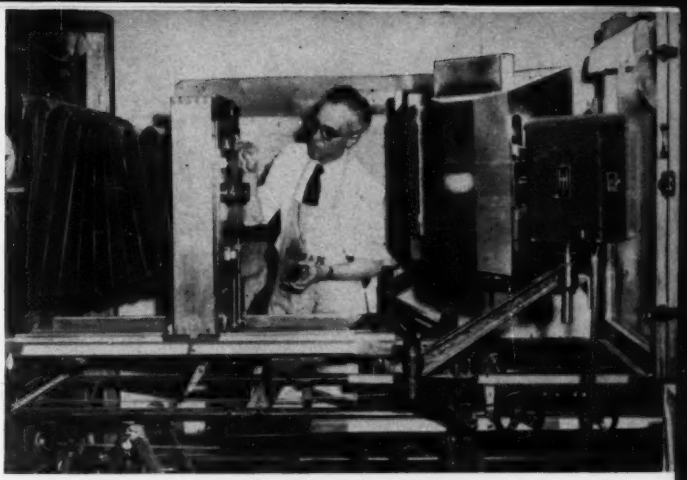
Below: Joe Kent touching up a composite made up of several negatives fitted together.

GRAVING

is then laid flat against a zinc or copper plate coated with a sensitized material, and the whole exposed under arc lights. The coating is developed and where there were crossed clear lines on the negative, there are holes in the coating.

The plate is then etched, the zinc by nitric acid, and the copper by ferric chloride, the etched lines leaving small raised dots on the plate. The plate is then cleaned of the remaining coating, and sent to the machine room, where the excess metal is routed out; the plate is then cut to size, and mounted on a board. If there are large routed areas, it can be nailed to the board; if not, it is mounted on a board coated with a plastic material, and the seal achieved under thirty tons pressure and a temperature of three hundred degrees Fahrenheit. The plate is then checked for imperfections, corrected, and a proof print made from it.

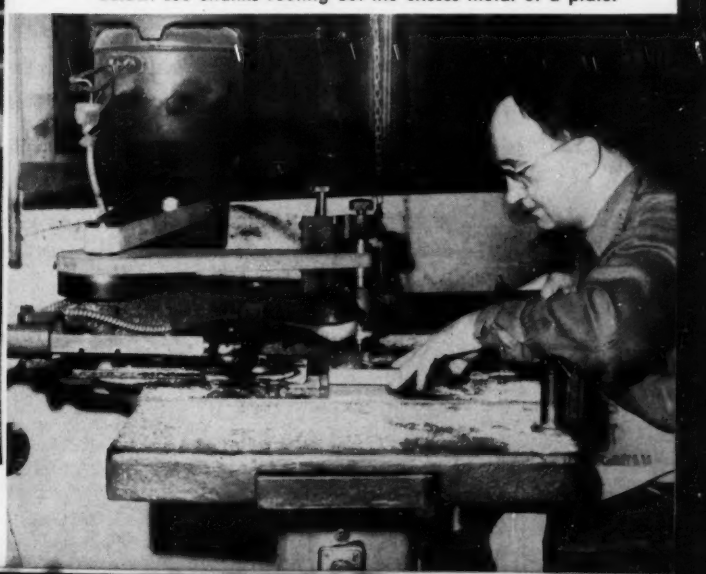
Ithaca Engraving also has an art department doing everything from retouching of prints to original advertising layouts, air-brush renderings from blueprints, and full color engraving drawing from sketches.



Above: Al Baron adjusting the lens of the 24" x 24" process camera used to photocopy the original. The camera is attached to the retouching stand and arc lights.

Left: C. E. Webb taking a proof of a cut from the proof press.

Below: Lee Shanks routing out the excess metal of a plate.



Photos by Ray Simon

ME...
an AIRCRAFT engineer?

But I haven't majored in aeronautical engineering

That doesn't matter. Lockheed can train you... at full pay!

It's your aptitude, your knowledge of engineering principles, your degree in engineering that count.

Those—plus the opportunity Lockheed is offering you—are all you need for a career as an aircraft engineer. In Lockheed's special program for engineering graduates, you may go back to school, or you may convert to aircraft work by doing—on-the-job training. But whichever it is, you receive full pay while learning.

But Lockheed offers you more than a career. It offers you a new life, in an area where living conditions are beyond compare. Outdoor living prevails the year-'round. Mountains, beaches are an hour from Lockheed.

See your Placement Officer today for the details on Lockheed's Aircraft Training Program for engineers, as well as the better living conditions in Southern California.

If your Placement Officer is out of the illustrated brochures describing living and working conditions at Lockheed, write M. V. Mattson, Employment Manager

Lockheed Aircraft Corporation

Burbank, California

This Plane made History

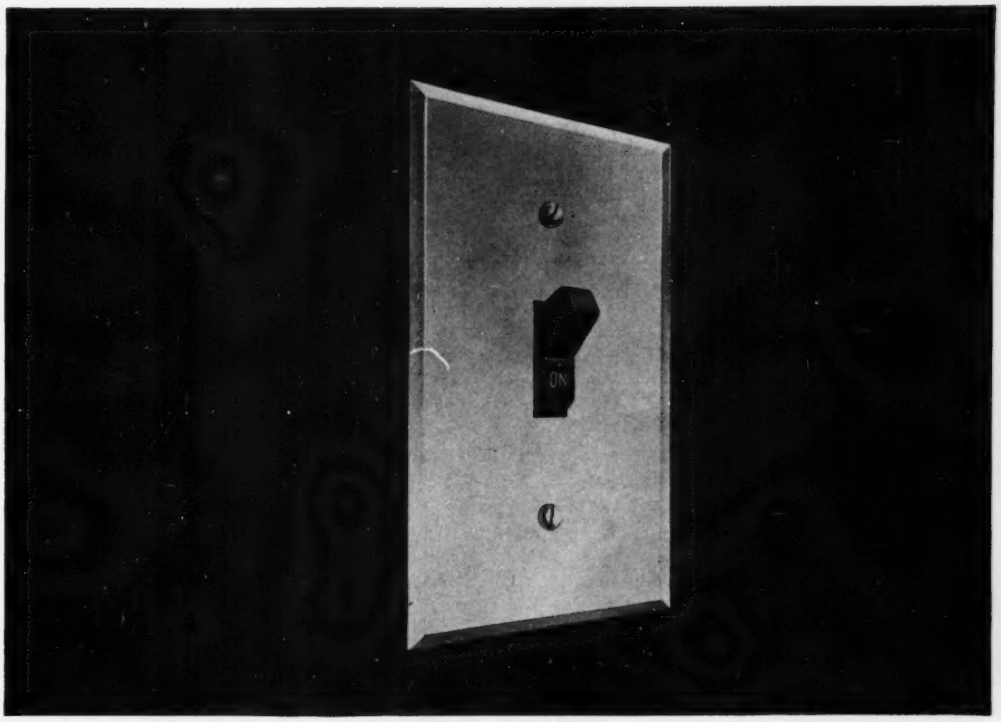
The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

This Plane is making History

The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

This Plane will make History

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.



KEY TO POWER...

It's just a simple switch. Yet it is the key that will unlock the energy generated by America's 20-billion dollar electric power industry.

Whether it's to light a room or a city . . . to start a kitchen mixer or a rock crusher . . . to heat milk for the baby or melt steel in an electric furnace . . . switches make you master of unseen electrical energy.

KEY TO PROGRESS...

Because myriads of scientists, physicists, engineers and designers have developed equipment to generate and utilize electric power, American workers produce more, earn more and enjoy a higher standard of living than those of any nation in the world.

Important, too, is the interchange and distribution of the ideas which have made this progress possible . . . the job of America's all-seeing, all-hearing and reporting Inter-Communications System.

THE AMERICAN INTER-COM SYSTEM...

Complete communication is the function, the unique contribution of the American business press . . . a great group of specially edited magazines devoted to the specialized work areas of men who want to manage better, design better, manufacture better, research better, sell better, buy better.

COMMUNICATION IS OUR BUSINESS...

The McGraw-Hill business publications are a part of this American Inter-Communications System.

As publishers, we know the consuming insistence of editors on analyzing, interpreting and reporting worthwhile ideas.

We know that businessmen, in order to keep abreast of their jobs, subscribe to—pay for—McGraw-Hill magazines that are edited for their specific business interests . . . for the editorial pages tell "how" and the advertising pages tell "with what."

McGRAW-HILL PUBLISHING COMPANY, INC.

330 WEST 42nd STREET, NEW YORK 36, N. Y.

HEADQUARTERS FOR BUSINESS INFORMATION

Trends In Jazz

First of Two Tau Beta Pi Prize-Winning Essays

By ROBERT CONTI, ME '53

Jazz has expressed at various times a variety of concepts, ranging from the roaring era of the twenties to the resounding rhythm of Stan Kenton. Basically, however, jazz is a form of American music characterized by intense personal emotional expression. Rhythmic drive and improvisation are emphasized, with the improvisation modified by the background and style of the performer.

Before concerning ourselves with the questions of the trends and future of jazz, it might be well to elaborate briefly on its origin and history. Although the exact source of its beginning is very controversial, it is generally agreed that several factors entered into the birth of jazz as a musical idiom. The African rhythms brought to the South by the slaves, the Negro blues, spirituals, and work songs all were readily adapted to jazz.

Jazz, then, was initially a means of expression for the Negroes, and the transition from vocal to instrumental expression was a natural one, aided greatly by the abundance of surplus Civil War band instruments. The Negro jazz bands soon became familiar sights at public functions. This was especially true in New Orleans, the cradle of American jazz, where these bands marched in weddings, festivals, and funerals. The tradition of emotional expression was maintained by these bands, despite the public nature of the performances. In the funeral processions, for example, the band played slow, lamenting blues, expressing the sorrow of the mourners. On the way back from the cemetery, however, quick step quadrilles such as "Didn't He Ramble!" were played, expressing the nature of the life led by the deceased.

These marching bands soon developed definite styles and began playing in small intimate groups. These groups, besides playing for their own enjoyment, found employment in the brothels of Storyville, the sprawling red-light district of New Orleans. This employment was an important factor in the growth of jazz, for the music now provided a means for fame and fortune for the Negro jazz musicians. This close association with the brothels also seems to substantiate the opinion of some authorities that the name of "jazz" had a vulgar origin.

Robert Conti, ME '53

Some jazzmen were carrying their music northward on the fiverboats that plied the Mississippi, but the main factor in the spread of jazz from New Orleans was the closing of Storyville by the Navy in 1917. The resulting unemployment caused the musicians to migrate in large numbers, mainly up the river to Chicago.

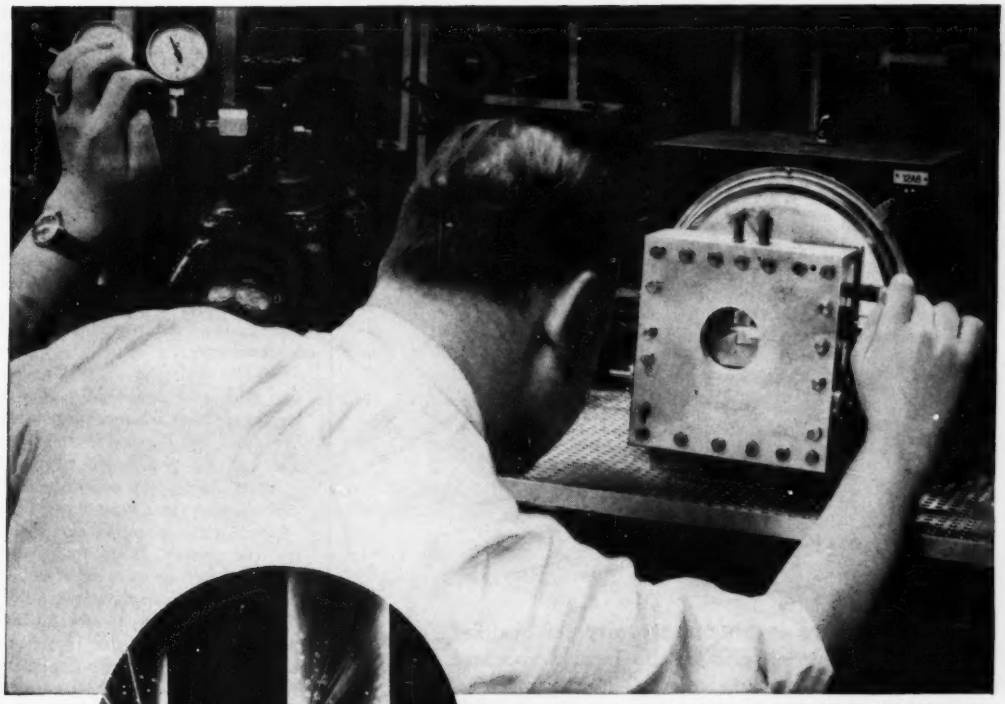
Such great jazzmen as Louis Armstrong, Earl Hines, and Bix Beiderbecke soon established Chicago as the new center of the jazz idiom. Their music inspired many young white musicians to imitate them and form what came to be known as the Chicago style. Although similar to the New Orleans style, the Chicago music was nervously explosive and lacked the easy, flowing power of expression possessed by the New Orleans bands. This Chicago school of white jazz fathered many famous musicians. Among them were Benny Goodman, Gene Krupa, Dave Tough, and Jess Stacy.

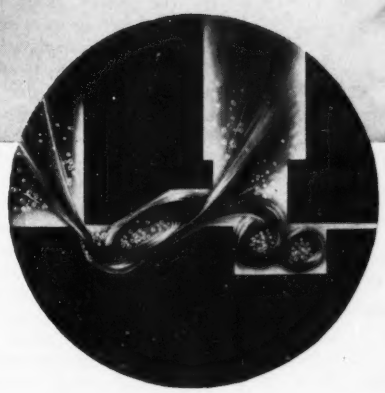
From Chicago, jazz spread to Memphis, Harlem, Kansas City, and other towns, where the idiom was kept alive in small-dive, hot jazz sessions. The pure jazz, however, was mainly musicians' music, unappreciated by the public, and the uncompromising exponents of hot music found it impossible for them to make a living and difficult for their music to flourish. The sweet bands of Guy Lombardo and Wayne King were in vogue commercially. The jazzman had to substitute a commercial compromise in place of his hot music in order to survive. That compromise was swing.

Most swing is admittedly good listening, but from the viewpoint of pure jazz, it was a degrading substitute. The very essence of jazz, that of creative improvisation, was replaced by written arrangements, necessary for the unity of a big band. Only occasionally, in the use of original jazz solos as part of the arrangement, was the pure idiom in evidence. Swing was here to stay and it swept the country like wildfire, mainly following the Pied Piper clarinet of Benny Goodman, the King of Swing.

The great success of swing tended to overshadow ramifications in the fields of classical and semi-classical music due to jazz. As in the case of swing, these musics borrowed the mechanics of jazz and utilized them in both rhythmic ideas and instrumentation. Although the body of jazz was used, the very soul of jazz, improvisation backed by rhythm, was once more ignored. Good examples can be heard in "Creation of the World" by Milhaud, in the classical field, and "Rhapsody in Blue" by Gershwin, in the semi-classical field.

The resounding success of "Rhapsody in Blue" touched off a school of composing called "symphonic jazz." As in the case of swing, it was good music but certainly not jazz. Soon jazz found itself being tied in with a great variety of musical accomplishments the world over. Authorities claimed that Stravinsky used ragtime music in his compositions. A relationship between the Chicago style and Bach was proposed, and it was said that Brahms was influenced by 1890 jazz.





This Sperry engineer is applying the fundamentals of hydraulics to determine oil flow characteristics at high pressure. Here he introduces nitrogen to the hydraulic fluid in a complex valve to make flow patterns visible for study.

There's Job Diversity at Sperry

FOR THE GRADUATE ENGINEER!

Right now there are openings for...

- Aeronautical engineers
- Electrical engineers
- Electronic engineers
- Mechanical engineers
- Physicists
- Technical writers
- Field engineers for applied engineering

In each field you work with leaders on interesting projects vital to the nation's well-being—long-range projects with a future—projects that call for originality and fresh thinking.

You share in Sperry's prestige

You'll be proud to say you're a Sperry Engineer. Because, as a member of the engineering staff, you'll share in a forty-year reputation for leadership. Today Sperry is the acknowledged leader in the field of automatic controls for navigation. From Sperry's work in gyroscopics and electronics have come the Gyropilot* flight controller, Zero Reader* flight director, Microline* test equipment, radar, servomechanisms, computing mechanisms, and communications equipment.

Attractive locations

Long Island—A pleasant suburban atmosphere convenient to New York. Modern plant. Well-equipped laboratories. Excellent working facilities.

In the Field—There are excellent applied engineering opportunities in various sections of the United States and abroad.

Good working conditions

The way is clear for steady advancement. You are encouraged to continue your education while you earn. And liberal employee benefits are provided for all.

Check your placement office for dates when Sperry representatives will visit your school ...or write Sperry employment section 1 A 5.

*T. M. REG. U. S. PAT. OFF.

SPERRY *GYROSCOPE COMPANY*
DIVISION OF THE SPERRY CORPORATION

GREAT NECK, NEW YORK • CLEVELAND • NEW ORLEANS • BROOKLYN • LOS ANGELES • SAN FRANCISCO • SEATTLE
IN CANADA • SPERRY GYROSCOPE COMPANY OF CANADA, LIMITED, MONTREAL, QUEBEC

Build a rewarding career as an S.S.White sales engineer...

Here is an opportunity for qualified engineering graduates to become associated with one of the country's leading manufacturers in a sales engineering job that will bring you in contact with top engineers in all branches of industry.

We are looking for graduate engineers who desire to utilize their engineering training in the sales and application of mechanical products in industry.

As an S.S.White sales engineer you will start at an attractive salary and be trained right on the job to undertake immediate responsibility.

Your opportunities for a lifetime career with S.S.White are unlimited. Promotions are made from within and your accomplishments will be quickly recognized and rewarded.

We will be glad to arrange an interview either at your school or in New York at the S.S.White Industrial Division offices. Write to Department C and include a snapshot of yourself and a brief resume of your education, background and experience.

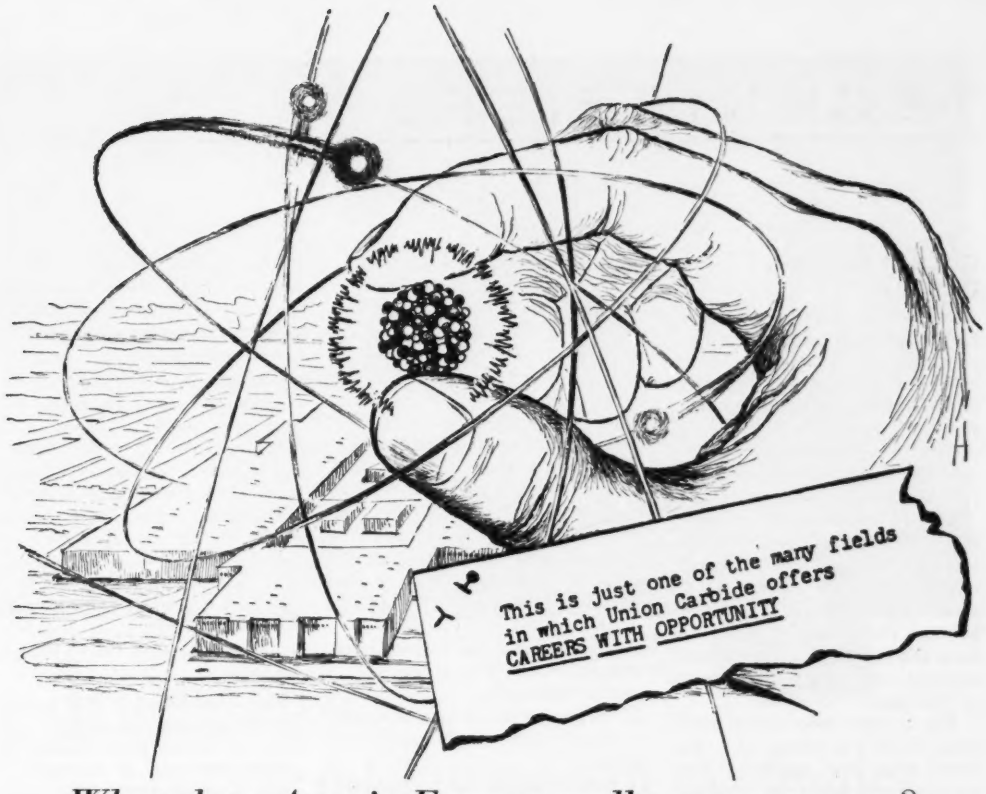
THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO. Dept. C. 10 East 40th St. NEW YORK 16, N. Y.

This whole "jazz" as an art school was mainly the result of two factors. The first was the great commercial success of the various music forms tied in with jazz. This prompted the coming of great numbers of jazz veneers, mere copies of the true idiom. The ever-present American self-consciousness about the smallness of her contributions to culture led many critics to dip a brush into the real and unpretentious hue of jazz and wildly flail the musical scene with it, attempting to color a multitude of musical achievements.

In the midst of these wanderings, the pure music of jazz was being kept alive by uncompromising hot musicians playing in the back alleys of the prohibition days and in dives during the depression-ridden thirties. Jazz has never been dependent upon public favor for its true growth. It grows because there are certain men who like to play it, and it is played in public because a sufficient number of laymen have shared the musicians' pleasure. These years developed the technical abilities of the jazz men, but the music remained real and unpretentious until 1944.

In 1944, the music of "be bop" or merely bop, was introduced in New York City. In some of its restrained phases this music was jazz. It emphasized small intimate groups and individual improvisation. It also, however, utilized extremely complicated rhythm patterns and stepped-up tempos, together with a great deal of technical scale rides. This tendency for the improvisation to degenerate from creative works to technical exhibitions produced a rift between bop and jazz. The introduction of certain European classical traditions into its form was also an important phase of bop.

This incorporation of formal European traditions and the unique experimentations with improvisation will be key factors in the future of jazz. This future will depend upon the degree to which pure jazz can absorb these elements and still maintain its true nature. Undoubtedly the classical traditions, improvisation experiments, and technical improvements will lead to new forms of American music. Whether or not this music will be jazz remains to be seen.



What does Atomic Energy really mean to you?

Dramatic new developments in medicine, agriculture, and industry promise long-time benefits for us all

Scientists have long known that the secret core of the atom concealed vast stores of concentrated energy. Evidence that man had unlocked the secret came with the atomic bomb.

Then came the task of developing methods to release this unbounded energy slowly, gradually, in ways of lasting benefit to all of us.

ISOTOPES AN EXAMPLE—When uranium atoms are split they emit a barrage of highly active particles. Certain chemicals placed in this barrage become radioactive and shoot off particles from themselves. Substances thus treated are called radioactive isotopes.

When these chemicals are made radioactive their paths can be traced through plants and animals, showing the organs they affect. This may increase our understanding of the processes of life itself.

FUTURE UNLIMITED—Atomic energy is also proving useful in industrial research and production. It promises to be even more valuable, however, in providing concentrated power for transportation, home, and industry.

UNION CARBIDE'S PART—From the beginning UCC has had a hand in the mining and treatment of uranium ores, the development of engineering processes, and the production of special materials for the atomic energy program. Under Government contract Union Carbide manages and operates the huge research and production installations at Oak Ridge, Tenn. and Paducah, Ky.

All of this activity fits in with the continuing efforts of the people of Union Carbide to transform the elements of the earth into useful materials for science and industry.

STUDENTS and STUDENT ADVISERS: *Learn more about the many fields in which Union Carbide offers career opportunities. Write for the free illustrated booklet "Products and Processes" which describes the various activities of UCC in the fields of* ALLOYS, CARBONS, CHEMICALS, GASES, *and* PLASTICS. *Ask for booklet D-2.*

UNION CARBIDE
AND CARBON CORPORATION
30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

UCC's Trade-marked Products of Alloys, Carbons, Chemicals, Gases, and Plastics include

SYNTHETIC ORGANIC CHEMICALS • EVEREADY Flashlights and Batteries • NATIONAL Carbons • ACHESON Electrodes • PYROFAX Gas
ELECTROMET Alloys and Metals • HAYNES STELLITE Alloys • PREST-O-LITE Acetylene
DYNEL TEXTILE FIBERS • BAKELITE, KRENE, and VINYLITE Plastics • LINDE Oxygen • PRESTONE and TREK Anti-Freezes

TECHNIBRIEFS

Constant Amplitude Oscillator

Changes in tube parameters, supply and heater voltage, or load impedance do not affect the r-f voltage of a new constant amplitude oscillator developed by the National Bureau of Standards. In principle, it consists of a conventional oscillator with a diode connected across the output terminals.

Adjustable frequency oscillators should be stabilized against changes arising from variations of circuit components. The new device steadies the apparent grid-plate gain of the oscillator, holds the input and output capacitances fairly constant, and reduces the clipping of the output waveform.

The clamper tube which maintains the output voltage at a relatively fixed level begins to draw plate current when the oscillator output voltage reaches a certain high level. This drawing of plate current reduces the plate voltage, and since the oscillator is connected to the same plate-dropping resistor, it too suffers a plate supply reduction.

Upon experimentation, the best regulating characteristics were found to be obtained when the largest plate-dropping resistor was used that still permitted the desirable plate voltages. A 10,000-ohm resistor permitted a 12-volt variation for a change in plate supply from 200 to 350 volts; but a 40,000-ohm resistor allowed only a 1.5-volt variation for the same change.

Improved clamping results when a voltage-multiplier type of rectifier is used to drive the clamper tube. Regulation is bettered since a greater ratio of d-c control bias to r-f output is obtained.

Phongraph Needle Drag Distortion

If a phonograph needle can move tangentially with respect to the grooves of an ordinary record, a National Bureau of Standards study has shown that the needle will not follow the groove perfectly, and "drag distortion" will result. This distortion causes spurious tones of greater amplitude than the tones originally recorded.

For best duplication of recorded music or information, the motion of the tip of the playback needle should exactly duplicate the original lateral motion of the recording stylus.

There are numerous possible causes for longitudinal motion. The uneven width of the record groove gives the well-known "pinch" effect. Another cause is the varying force exerted by the groove against the stylus. Still a third is the change in friction produced from the pressure and velocity of the needle in a groove.

Both mathematical analysis and laboratory experimentation were included in the NBS study. The former involved introduction of harmonics due to the longitudinal motion. Sudden transitions from one amplitude to another change the longitudinal force on the stylus, which gives rise to drag distortion if the needle is not restrained properly in this direction.

For some of the experimental work, a thin steel wire was welded to the needle near its tip. Longitudinal motion was minimized when the needle was tied back with this wire. An oscilloscope indicated the longitudinal displacement of the needle tip.

The NBS investigators pointed out that the styluses of the better modern pickups have high longitudinal stiffness. With these, drag distortion is practically negligible.

Rapid Gas Sampler

A mechanical device that takes samples of a rapidly changing gas over intervals of 0.2 millisecond or less has been developed by the National Bureau of Standards. Its primary purpose is for research on engine "knock"; the new sampling valve is well adapted to study of complex changes taking place in automotive engines.

The Bureau is now studying the reaction kinetics of knocking combustion in order to obtain information which will make possible more efficient utilization of automotive fuel. A wide range of operating conditions may be simulated in a one cylinder test engine specially constructed for these studies. The data obtained from the ignition of the fuel-air mixture is being used to correlate the knocking characteristics of fuels with their chemical structure.

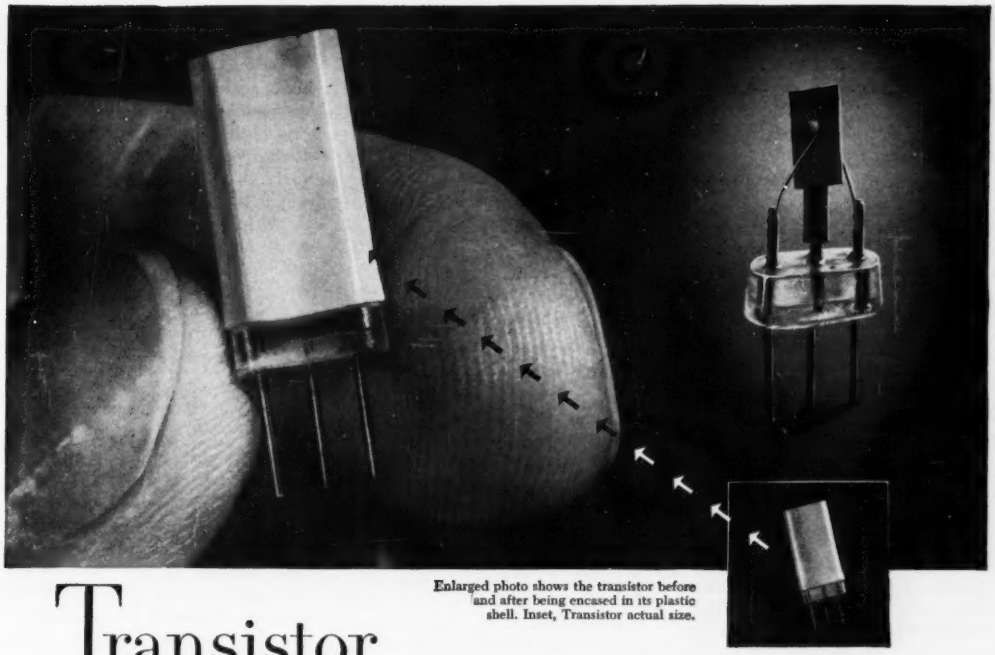
Some knowledge of the proportion of reactants and products present at various times during the combustion cycle is necessary in order to obtain data on the chemical processes taking place in the cylinders. These are naturally hard to study because of the short duration of each phase of the cycle (0.1 to 1 millisecond). The samples must be taken over extremely short intervals, but must be large enough for analysis in a mass spectrometer.

The NBS sampler, developed to meet these requirements, consists essentially of a flanged piston in an evacuated chamber. The upper end is connected to a vacuum pump and an evacuated sample container. The lower end is wide, but narrows to connect with the combustion chamber.

Upon combustion, the piston forces the gases into the sample container, where they are sealed off as the flange seats the piston head. A photo-electric cell arrangement indicates time of opening and closing of the valve.

High Speed "Brains"

The more that jet planes increase in speed, climbing ability, and in other aspects of performance the



Enlarged photo shows the transistor before and after being encased in its plastic shell. Inset, Transistor actual size.

Transistor—

mighty mite of electronics

Because of growing public interest in transistors, RCA—a pioneer in their development for practical use in electronics—answers some basic questions:

Q: ***What is a transistor?***

A: The transistor consists of a small particle of the metal germanium imbedded in a plastic shell about the size of a kernel of corn. It controls electrons in solids in much the same way that the electron tube handles electrons in a vacuum. But transistors are not interchangeable with tubes in the sense that a tube can be removed from a radio or television set and a transistor substituted. New circuits and components are needed.

Q: ***What is germanium?***

A: Germanium is a metal midway between gold and platinum in cost, but a penny or two will buy the amount needed for one transistor. Germanium is one of the basic elements found in coal and certain ores. When painstakingly prepared, it has unusual electrical characteristics which enable a transistor to detect, amplify and oscillate as does an electron tube.

Q: ***What are the advantages of transistors?***

A: They have no heated filament, require no warm-up, and use little power. They are rugged, shock-resistant and unaffected by dampness. They have long life. These qualities offer great opportunities for the miniaturization, simplification, and refinement of many types of electronic equipment.

Q: ***What is the present status of transistors?***

A: There are a number of types, most still in the development stage. RCA has demonstrated to 200 electronics firms—plus Armed Forces representatives—how transistors could be used in many different applications.

Q: ***How widely will the transistor be used in the future?***

A: To indicate future applications, RCA scientists have demonstrated *experimental* transistorized amplifiers, phonographs, radio receivers (AM, FM, and automobile), tiny transmitters, and a number of television circuits. Because of its physical characteristics, the transistor qualifies superbly for use in lightweight, portable instruments.

* * *

RCA scientists, research men and engineers, aided by increased laboratory facilities, have intensified their work in the field of transistors. New applications in both military and commercial fields are being studied. Already the transistor gives evidence that it will greatly extend the base of the electronics art into many new fields of science, commerce and industry. Such pioneering assures finer performance from any product or service trade-marked RCA and RCA Victor.

CONTINUE YOUR EDUCATION WITH PAY—AT RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short-wave and FM circuits, television, and phonograph combinations).
- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to College Relations Division, RCA Victor, Camden, New Jersey.
Also many opportunities for Mechanical and Chemical Engineers and Physicists.

RCA

RADIO CORPORATION OF AMERICA

World leader in radio—first in television

more assistance that must be given the pilot in the way of automatic controls. These devices are almost as amazing as the planes themselves. The Westinghouse autopilot flies the plane automatically, whether cruising leisurely or at high speed for fast maneuvering combat.

Among the airplanes making use of the autopilot is the Lockheed F-94C Starfire, most powerful of all single-engine jets now in production. It is a two-man aircraft in the 600 m.p.h. class and can climb to 45,000 feet or higher. After take off, ground radar observers direct the air plane by radio toward the target. When near the target, the pilot turns on instruments which electronically track down the enemy, aim the airplane, and fire up to 24 rockets from a ring of tubes in the nose.

The Westinghouse autopilot is unique in the use of rapidly spinning "rate" gyroscopes as primary sensing elements for following the movements of the airplane during all maneuvers. They differ in this respect from ordinary "position" gyros, which are not locked to the airplane and hence resist any effort to change their direction of motion. Position gyros are sensitive only to changes in the attitude of the airplane, whereas the "rate" gyros of the Westinghouse autopilot respond only to the rate at which such changes take place.

The flight controller of the autopilot, a single knob, affords virtual finger-tip control of the movement of the airplane. To climb, the pilot pulls the knob back and the plane responds at a constant rate, regardless of external conditions. To turn, he rotates the knob either right or left. The turn is executed at once at a rate depending on the amount the knob is turned, with the correct back angle automatically set for proper coordination.

For combat maneuvers, the pilot switches the autopilot to a mode of operation which gives him complete manual control, but which introduces the necessary rate damping to eliminate the hazard of making a maneuver too rapidly for the high-speed aircraft. The control reacts to the pilot's signal in less than one-fifteenth second, and the hydraulic flight controls "boost" the pilot's effort some 15 times.

The autopilot works through this same system in automatically piloting the aircraft. It is tied into the plane's radar and instrument landing system, helping it to track enemy targets automatically and to land in bad weather.

The autopilot is suitable for both large and small commercial airplanes as well as military aircraft. Radio-controlled, it can also serve to direct the flight of guided missiles and pilotless aircraft.

X-Ray Amplifier

Radiologists and physicians now have a new tool in the X-ray image amplifier—a device that will give them a 200 times brighter view of their patient's internal organs in living action. An attachment for standard fluoroscopic equipment, the image amplifier is now going into production at the Westinghouse X-ray Division in Baltimore, Maryland, after eight years of intensive research. Basically, the amplifier consists of a high-vacuum tube that electrostatically focuses and accelerates an electron stream.

The conditions confronting the physician in present-day fluoroscopy are comparable to those encountered in finding a seat in a movie after leaving the bright sunshine. To see the fluoroscopic image, the radiologist has to dark-adapt his eyes for at least 20 minutes. Now, with the image amplifier attached to his equipment, the physician can step into his dark room and see at once a bright image. He may still have to dark-adapt his eyes, though for only three or four minutes, before he can see all the details. What he sees will be a clear, easily discernible presentation of his patient's organs at work.

The new image amplifier increases the brightness of the fluoroscopic image after the X-rays have passed through the patient. This solution to the problem is necessary because the X-ray intensities are already approaching the patient's tolerance level.

Increased brightness of the X-ray image has been attained by converting the X-ray energy into light with a fluorescent screen, and thence to electrons by means of an adjacent photoelectric surface. These electrons are accelerated by a high potential placed across the vacuum tube, giving a brightness gain of 10 or more. A further gain is attained by electrostatic focusing of the electron stream to reduce the image to approximately one fifth its original size. The reduced image, made up of high speed electrons, impinges on a phosphor output layer that converts the electron stream back to a visible image, now brightened 200 times or more. As a final step, the intensified image is magnified by means of an optical system without loss of the increase in brightness.

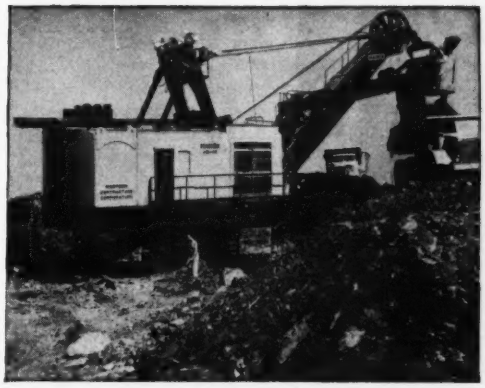
The intensification achieved by reducing the image size in the electron-optical system is possible because the brightness is increased in inverse proportion to the area. This is so because all the electrons are utilized in forming the image. When the area is reduced, the total energy therefore remains constant. Thus the energy per unit area, which is proportional to brightness, must go up. Limitations of the optical magnification that can be obtained without loss of brightness or limitation to the freedom of position of the observer make it unprofitable to reduce the electron image to less than one fifth the size of the X-ray image. The reduced image seen through an ordinary optical magnifier appears in its original size with negligible loss of the brightness gained in the electron-optical reduction.

Now commercially available, the image amplifier can be used as an attachment to present-day X-ray fluoroscopic equipment. Since all the work is done after the X-rays leave the patient, the new development will in no way affect the basic design or operating principles of existing equipment.

New Spectrometer

An advanced high-sensitivity Norelco Spectograph, a new ninety-degree Geiger-counter X-ray Spectrometer, the Philips Electron Microscope, and a number of other

Another page for **YOUR BEARING NOTEBOOK**

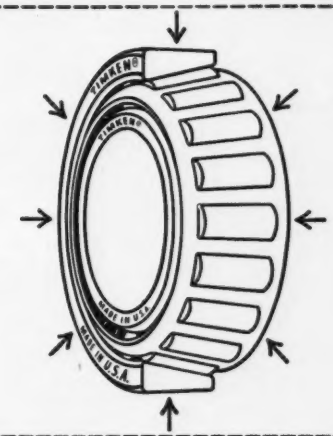


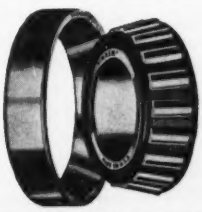
Largest two-crawler shovel keeps going on TIMKEN® bearings

Designed to meet the trend toward larger excavating and hauling units, Marion Power Shovel Co., built a new 10-cubic yard 191-M shovel with a production potential of over 600,000 yards a month. To keep it on the job every day of the month with minimum maintenance, Marion engineers equipped it with Timken® tapered roller bearings at all vital points. Timken bearings carry radial and thrust loads in any combination. Their true rolling motion and smooth finish practically eliminate friction. By keeping housing and shaft concentric, they make closures more effective. Lubrication time and costs are cut.

All loads are the same to a TIMKEN bearing

The tapered design of cup, cone and rollers of Timken bearings enables them to take radial loads, thrust loads, or any combination of the two from any direction. Timken bearings do away with the need for auxiliary thrust bearings or plates. They simplify design, cut costs, save space.





TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

Want to learn more about bearings?

Some of the engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help. For a copy of the 270-page General Information Manual on Timken Bearings, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL ⬭ AND THRUST ⬭ LOADS OR ANY COMBINATION ⬭

instruments for analytical work will be on display in the U. S. Bureau of Mines section of the Hall of Science at the International Petroleum Exposition to be held in Tulsa, Okla., May 14-23, 1953.

The half million domestic and foreign visitors from petroleum, chemical, mining, geological, and metallurgical fields who are expected at this petroleum exposition will be able to obtain first-hand information on many types of problems involving the use of the electron microscope, the Geiger-counter X-ray spectrometer, the X-ray spectrograph (fluorescence analysis), and film-type X-ray diffraction equipment. Of interest will be current applications of X-ray analysis in the development of greases and lubricating oils, particularly in the detection of vanadium and other agents which poison catalysts, and in studies of bearing metals in lubricants.

Metals Studies

Knowledge of the orientation of crystals of metals is often of practical importance, but no generally satisfactory method has been available for determining the orientation of the small crystals found in commercial metals. Because of the need for such a method, the National Bureau of Standards is investigating the possibility of estimating crystal orientation from measurements of changes in the characteristics of polarized light. Results so far indicate that, in the case of the industrially important alloy of 70 nickel and 30 copper (Monel), crystal orientation can be correlated with extinctions of polarized light.

X-ray diffraction methods of determining crystal orientation have been attempted, but cannot be applied conveniently to small crystals. The metallurgical microscope is convenient for observing small crystals, but its use is generally limited to showing differences in orientation qualitatively. In recent years, these microscopes have been equipped so that the specimen can be illuminated with plane-polarized light. When a metallographically polished and optically active surface is examined with such an arrangement, characteristics of reflected polarized light change measurably from crystal to crystal.

Although metals having a cubic crystal structure are not inherently optically anisotropic, the surfaces of many such metals, including Monel, become optically anisotropic after etching with conventional metallographic reagents. The angular positions of the polarized-light extinctions of Monel differ for adjacent crystals, and it was found that these positions remained the same after repolishing and re-etching. It seemed to follow that the apparent optical anisotropy, being thus independent of the etching treatment, could probably be correlated with crystal orientation.

Examination of annealed Monel specimens showed clusters of crystals in which each crystal was adjacent to at least one annealing twin. (A twin relationship is indicated in a polished and etched surface when two crystals are separated by a straight line.) It was also observed that some of the clusters contained a crystal whose straight-line boundaries were in four different directions.

The NBS study also indicates that the optical anisotropy exhibited by Monel is caused by parallel furrows in the surface and not, as has sometimes been suggested, by a film. The furrows are apparently formed by the tendency of the etching reagent to produce etch pits whose facets are parallel to cubic planes.

Coronograph

Mechanical mounts for the two largest and most powerful and accurate instruments ever built to study the sun's corona are now undergoing tests at the Sunnyvale, Calif., plant of Westinghouse Electric Corporation. The instruments are called coronagraphs.

After completion of "dry runs" on these instruments, using electronic devices to double for the missing giant lens and sun, special optical systems and instruments will be installed. The two coronagraphs will then probe the sun's secrets from high-altitude, dust-free and haze-free observatories atop Fremont Pass in the Colorado Rockies, and Sacramento Peak, near High Rolls, N. M. The first one completed will be located at Sacramento Peak and is scheduled to be in operation by this fall.

Scientists, through use of the two giant telescopes, hope to gain additional information about the sun's corona that will: (1) make possible highly accurate long-range terrestrial weather forecasting; (2) enable further progress in forecasting sun-caused disturbances that often black out or cripple the world's radio communications and interfere with radar operation; (3) unlock additional secrets of the atom; and (4) yield further keys to supersonic flight in the stratosphere and even higher—into the ionosphere and above.

Turbine Truck

Several months ago a 55,000-lb. truck-trailer dashed down the Pacific Coast from the Canadian to the Mexican border in less than 60 hours. What was most remarkable about this trip was that the truck, to outward appearance a standard Kenworth, was powered by a Boeing gas turbine weighing only 200 pounds. Other tests since have confirmed the successful results of this run.

The new engine has no radiator or cooling system and only one-tenth as many parts as a comparable diesel or gasoline power plant. Without reciprocating parts, it develops 175 horsepower in a package which is 3,000 pounds lighter than the diesel it replaced.

The power section consists of a centrifugal-type compressor, which sucks in large volumes of air and packs it into two combustion chambers. Fuel burned in these chambers expands tremendously, and the exhaust gases rush through a turbine wheel, which spins at 36,000 rpm to power the compressor. From this turbine, the exhaust blast is projected to another turbine which is geared to the truck's drive shaft. Whirling at 22,650 rpm, this turbine actuates a train of 8.62 to 1 reduction gears, which give the drive shaft a rotational speed of 2,500 rpm.

Assignment: *Accuracy*
Solution: *Subminiaturization*

Sylvania-Engineered, Capsule-Sized Radio Tubes Add Deadly Electronic Accuracy to Gun Fire

"Needed: a high-performance radio tube—rugged enough to meet battle conditions — small enough for compact military equipment."

A tough job? — YES. But typical of Sylvania's advanced, vital engineering assignments whose solutions unlock doors to the future.

Finding answers to such problems is the basis of Sylvania's continuing growth and leadership. If that's the kind of engineering you're looking for—we're looking for you!

For information on Sylvania's program for graduating engineers—see your Placement office today—or write Supervisor of Technical Employment . . .

Typical Sylvania subminiature tube 1¼" long, pencil thin—heart of vital electronic equipment.

SYLVANIA

Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.

LIGHTING • RADIO • ELECTRONICS • TELEVISION

There is no mechanical connection between the turbines. One actuates the other much like a fluid drive mechanism in an automobile, thus providing an infinitely variable transmission which precludes stalling under any load conditions.

Engines are currently being built for the Navy, which will use them to generate electric power aboard minesweepers. Although details are not available, the engine is also being service-tested as a power plant for personnel boats, helicopters, landing craft, light aircraft and military ground vehicles. Future installation plans include its use as auxiliary power for large aircraft.

Concrete Tests

While considerable data have been collected on the strength of various types of concrete under static conditions, relatively little is known about their resistance to impact. Yet such information is of vital importance in designing structures to withstand explosive blasts and earthquakes. In results obtained thus far the dynamic compressive strength of concrete was found to be up to 84 percent higher than the static strength, and the modulus of elasticity up to 47 percent greater.

The compressive strength and modulus of elasticity of concrete are usually determined by testing 6-by 12-in. cylinders under essentially static conditions. Data thus obtained are adequate for design calculations on structures subjected to static loads, but may not give results applicable to impulsive loads in which the peak value and subsequent attenuation of the force may take place in a fraction of a second. Studies of the effect of loading rate on the elastic properties of plain concrete have been until now confined to rates of straining less than 2×10^{-3} in./in. per sec. In the current study, the rate of straining of the concrete has been over the wide range 10^{-6} to 10 in./in. per second, a range made possible by recent advances in the technique of measuring stresses and strains with bonded-wire strain gages.

In the NBS investigation, 3-by 6-in. cylinders were subjected to standard static tests in a 60,000-lb. hydraulic machine and to impact tests in a specially designed drop-hammer machine at various rates of loading up to 10 in./in. per second. The total duration of the impact corresponding to the latter rate of loading was 0.0003 sec. "Softer" impact tests having a duration of about 1 second were made in a hydraulic machine running at full speed. Two types of concrete were used: a "weak" concrete of 2500-psi nominal static compressive strength, and a "strong" concrete of 6500-psi nominal static compressive strength.

The drop-hammer machine consisted essentially of a 3200-lb steel anvil for supporting the test specimen, a 140-lb drop-hammer, and a device for catching the hammer on the rebound. The hammer tip, which made contact with the test specimen, had a flat surface. Four compression springs supported the anvil, which was limited in its travel by four shock absorbers and two rubber buffers between the bottom of the anvil and the concrete base of the machine. The anvil was constrained to motion in a vertical plane by means of two hinged sway plates, one at each end of the anvil, which were anchored to the concrete wall back of the machine.

The maximum height of drop was 5.5 feet, and the maximum velocity of the hammer was about 19 feet per second. Various types of rubber buffers placed on top of the capping plate of the specimen controlled the duration of impact.

The dynamic compressive strength of a given type of concrete was found to be higher than the static compressive strength, becoming relatively greater as the duration of impact decreased. The ratio of the dynamic to static strength for the "weak" concrete ranged from 1.09 for a 0.9-sec. impact to 1.84 for a .00025-sec. impact. The corresponding ratio for the strong concretes ranged from 1.13 for the longer impact to 1.85 for a .00043-sec. impact.

The modulus of elasticity of the concrete was affected in a manner similar to the strength, that is, the ratio of dynamic to static modulus increased as the duration of impact decreased, reaching a maximum of 1.47 for the "weak" concrete and 1.33 for the "strong" concrete. The linear portions of the stress-strain curves became longer and steeper as the duration of impact was decreased. The ratio of strain energy absorbed under dynamic loading to that absorbed under static loading reached a maximum of about 2.2 for both concretes tested.

The significant increases in compressive strength, elastic moduli, and ability to absorb strain energy under impact loading are of importance to the designer. Further studies of the effect of impact on concrete in flexure are in progress, to enable the designer to take account of the potential saving of material in structures to be erected where they may be subjected to earthquakes, to bomb blasts, or to similar impact loading.

This Month's Brain Teaser

A certain flea has the following property: The probability that the flea jumps in any small time interval of length h is Ch. Only values of h such that Ch is greater than 1 are considered. Given that the flea is sitting motionless at time t equals O, find:

a) The probability that the flea jumps in the interval (t, t+dt).

b) The probability that the flea is still there at a given time t.

It took a lot of engineering to make a better "grasshopper"

Engineers at Western Electric's St. Paul Shops are well pleased with their new-style "grasshopper" fuse—a small fuse used in Bell telephone central office equipment. The former model—in production for years—had been gradually refined 'til it seemed almost beyond further improvement. It was simple, inexpensive, efficient, came off the line fast. But . . .

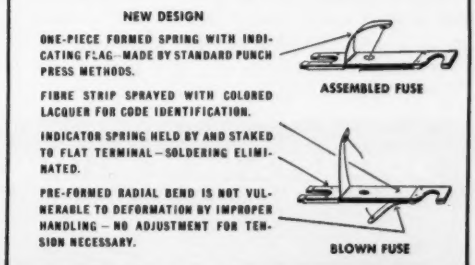
It's an old Western Electric engineering custom to keep trying to make Bell telephone equipment still better, at still lower cost. The "grasshopper" was studied by a young engineer out of the University of Minnesota, Class of '40, who joined the Company in 1946. His studies indicated the most effective way to improve efficiency and cut costs further was to change the design.

Pursuing this lead the engineer and his group saw their opportunity to make an important contribution. They investigated the latest tooling techniques, new metals, finishing materials and methods, all of which are constantly under study by engineers at Western Electric plants. A simplified design, which permitted the use of the most modern tooling methods, resulted in a better fuse at lower cost that is saving thousands of dollars a year for Bell telephone companies.

There's an endless stream of such challenging assignments at Western Electric. Engineers of varied skills—mechanical, electrical, civil, chemical, metallurgical—find real satisfaction in working together on the important job of providing equipment for the best telephone service on earth.

How the grasshopper fuse works

Small fuses like this are used by the millions to protect certain telephone central office circuits against current overloads. Odd in appearance, the fuse is called the "grasshopper" because of its spring which is released when the fuse blows, displaying an indicator "flag" in open view and tripping an alarm so the trouble can be spotted and corrected at once.


NEW DESIGN
ONE-PIECE FORMED SPRING WITH INDICATING FLAG—MADE BY STANDARD PUNCH PRESS METHODS.
FIBRE STRIP SPRAYED WITH COLORED LACQUER FOR CODE IDENTIFICATION.
INDICATOR SPRING HELD BY AND STAKED TO FLAT TERMINAL—SOLDERING ELIMINATED.
PRE-FORMED RADIAL BEND IS NOT VULNERABLE TO DEFORMATION BY IMPROPER HANDLING—NO ADJUSTMENT FOR TENSION NECESSARY.
ASSEMBLED FUSE
BLOWN FUSE

• *Engineer and punch press operator check production of parts for newly designed grasshopper fuse.*

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

BOOK REVIEW

Joseph Liston: *Power Plans for Aircraft*. 577 pages. McGraw-Hill Book Co. $8.50.

This is a textbook intended for upperclass undergraduates or first-year graduate students. It is remarkable in its scope. The author has tried to touch upon all the various kinds of aeronautical power plants and practically all their mechanical features, operating principles, and design problems. He has also tried to set forth in most cases the fundamental equations of the processes involved. The result is an information-packed book which, the author believes, can serve for either a short survey course or as part of a more extended program of studies of power plants.

It is quite up-to-date. In each chapter (fuels, charge-handling, performance, etc.) attention is given to turbine engines as well as reciprocating types, and, where appropriate, rockets, ram-jets, and even nuclear engines are discussed too. (To be sure, the greatest part of the book goes to reciprocating engines.) We find here the very modern matters of supersonic compressors, ceramics, and sweat cooling—as well as an interesting section on aircraft engines of days past. Nearly everything of concern to a power-plant engineer seems to be mentioned, usually with sketches and photographs, although some will be found in rather unexpected places. Cooling and the design of cowling are found, for example, under "Structural and Mechanical Requirements," while the chapter entitled "Performance" is devoted to a considerable extent to the subject of instrumentation. However, this question of organization is probably a secondary one, and it is more important to note that the material included in both these cases is well selected and clearly presented.

I seldom review a book without mentioning a few shortcomings, and this is not an exception. Being an aerodynamicist, I find some descriptions of aerodynamic phenomena inadequate; examples are: (1) an explanation of blade stalling which does not mention the boundary layer, and (2) the absence (as far as I can find) of any definition or description of a shock wave—although "shocks" are mentioned several times, and they provide the basic principle of the supersonic compressor. There does not seem to be any mention of the problem or techniques of tail-pipe cooling. The index is very incomplete and inadequate. As is usually the case in engineering textbooks, there is a tendency to present formulas in a very dogmatic way. It is not considered necessary to explain to student engineers why such-and-such a dimensionless coefficient is introduced, instead of some other; in most cases there is a good scientific reason that could be mentioned easily and concisely.

I have no idea whether Liston's book will be selected as a textbook for any of Cornell's engine courses. In any case it seems certain to provide a very useful, almost encyclopaedic, reference work for engineers who come in contact with the aeronautical or aero-engine fields.

W. R. Sears, Director
School of Aeronautical Engineering

● LEROY* Lettering equipment is standard in drafting rooms everywhere. No special skill is needed for perfect, regular lettering and symbol drawing. There are LEROY templates in a variety of alphabets and sizes, as well as for electrical, welding, map, geological, mathematical and other symbols that the draftsman needs. *Trade Mark®

KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
Chicago • St. Louis • Detroit • San Francisco • Los Angeles • Montreal

K+E
Drafting, Reproduction and Surveying Equipment and Materials, Slide Rules, Measuring Tapes.

to the

ELECTRICAL ENGINEER

or

PHYSICIST

with an interest in

RADAR

or

ELECTRONICS

Hughes Research and Development Laboratories, one of the nation's leading electronics organizations, are now creating a number of new openings in an important phase of their operation.

Here is what one of these positions offers you:

THE COMPANY

Hughes Research and Development Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar systems, electronic computers and guided missiles.

THE NEW OPENINGS

The positions are for men who will serve as technical advisors to government agencies and companies purchasing Hughes equipment—also as technical consultants with engineers of other companies working on associated equipment. Your specific job would be essentially to help insure successful operation of Hughes equipment in the field.

THE TRAINING

On joining our organization, you will work in the Laboratories for several months to become thoroughly familiar with the equipment which you will later help users to understand and properly employ. If you have already had radar or electronics experience, you will find this knowledge helpful in your new work with us.

WHERE YOU WORK

After your period of training—at full pay—you may (1) remain with the Laboratories in Southern California in an instructive or administrative capacity, (2) become the Hughes representative at a company where our equipment is being installed, or (3) be the Hughes representative at a military base in this country—or overseas (single men only). Compensation is made for traveling and moving household effects, and married men keep their families with them at all times.

YOUR FUTURE

In one of these positions you will gain all-around experience that will increase your value to our organization as it further expands in the field of electronics. The next few years are certain to see large-scale commercial employment of electronic systems. Your training in and familiarity with the most advanced electronic techniques now will qualify you for even more important future positions.

How to apply:

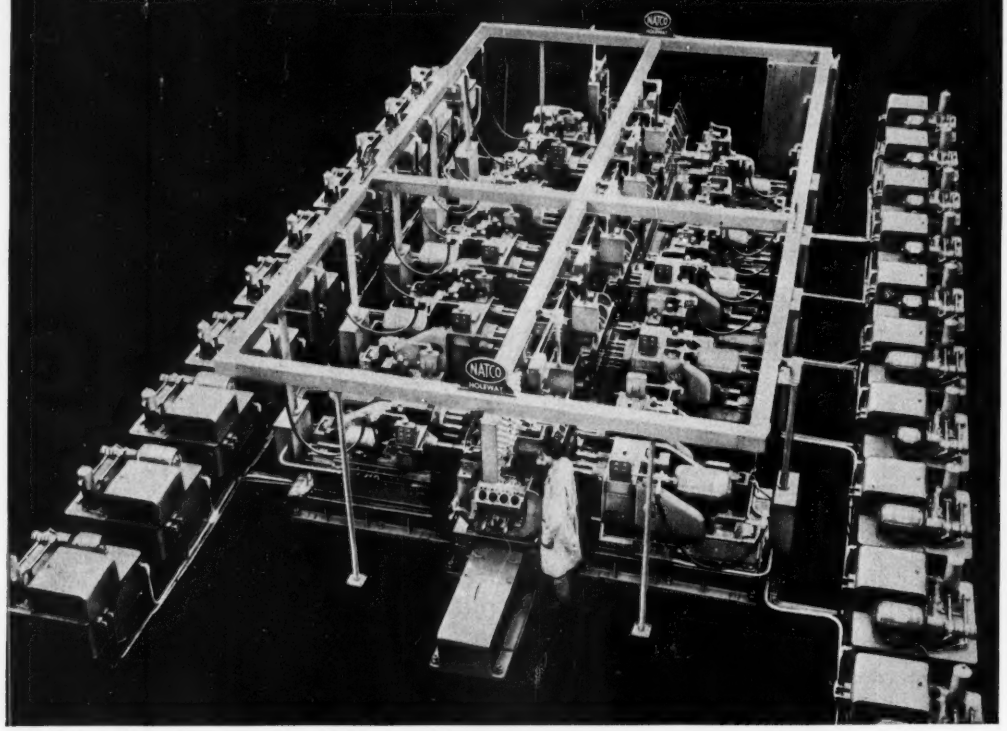
HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Scientific and Engineering Staff
Culver City, Los Angeles County, California

See your Placement Office for appointment with members of our Engineering Staff who will visit your campus. Or address your resumé to the Laboratories.

COULD YOU *ENGINEER* THIS MACHINE?



NATCO *HAS CHALLENGING OPPORTUNITIES...*

FOR DEVELOPMENT, DESIGN, SALES AND INDUSTRIAL *ENGINEERS*

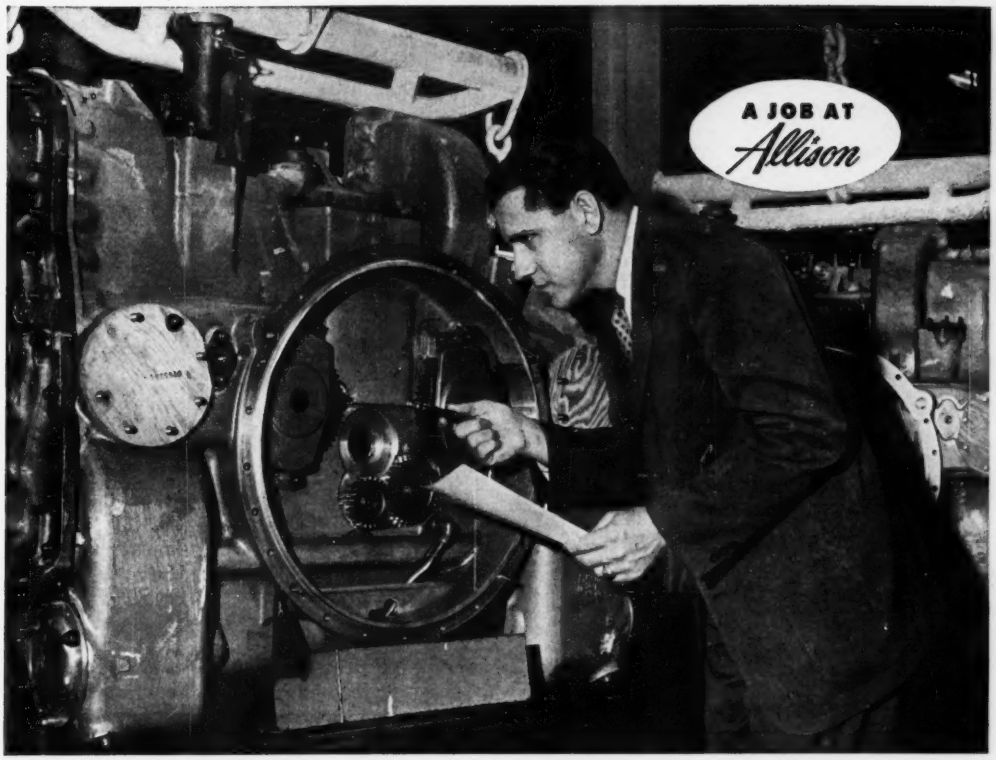
NATCO is a recognized leader in the machine tool field, having passed a half century of loyal service to industry.

Each NATCO machine is individually engineered to our customers' exacting requirements. Development, design, sales and industrial engineers are needed to help carry on this exacting work.

To accept this challenge, you are invited to contact your placement office or the Personnel Director of NATCO.

National Automatic Tool Company, Inc.
RICHMOND, INDIANA

NATCO



● B. F. "Bernie" Hartz received his B. S. degree in Mechanical Engineering in 1937 from the University of Notre Dame and today is a Senior Project Engineer in the Allison Transmissions Operation.

Bernie's job is to correlate the design, drafting, testing, and installation of the CD-850 cross drive transmission in Army Ordnance vehicles. This big 3000 pound transmission has more than 4000 parts and is used in the M-46 and M-47 General Patton tanks, cargo carriers, gun motor carriages and landing vehicles. It actually combines power steering, automatic torque multiplication, hydraulic quick-shifting and braking in a single unit.

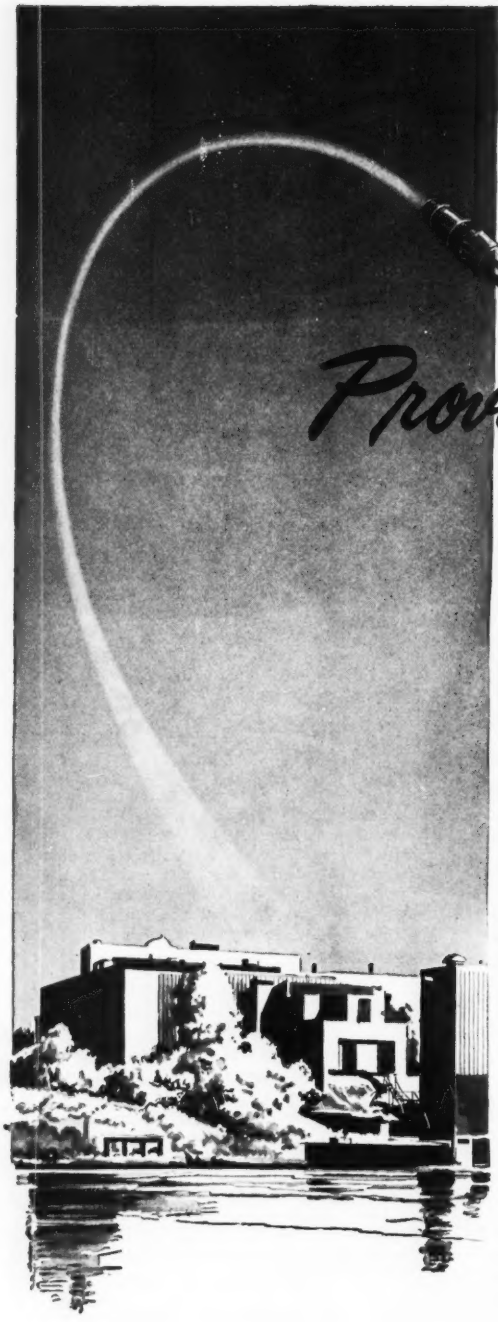
One of Bernie's recent assignments was to guide and direct the design, test and development of a more efficient steering system. The CD-850 transmission steers the 47 ton Patton tank by means of hydraulically actuated multiple disc clutches. This makes it possible to steer the massive vehicle, through the control valve body assembly, with a minimum of driver effort. The change required a vast knowledge of all of the components of the transmission which were affected by the new method. New designs had to be drawn and checked and many tests were run at Allison, General Motors Proving Ground and Aberdeen Proving Ground.

This is another of the engineering problems that Allison engineers are called upon every day to solve. Through new designs and improvements, Allison men are helping to give the Ordnance Department the best military vehicles in the world. Allison also has a progressive commercial heavy duty Torqmatic converter and transmission program which offers new fields for young men who want lifetime careers in engineering.

Allison is looking for young men with degrees in **MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, AERONAUTICAL ENGINEERING.** ***There are also a number of openings for majors in Metallurgy, Electronics, Mathematics and Physics.*** Write now for further information: R. G. Greenwood, Engineering College Contact, Allison Division, General Motors Corporation, Indianapolis 6, Indiana.

Allison **DIVISION GENERAL MOTORS CORPORATION • Indianapolis, Ind.**

Design, development and production—high power TURBINE ENGINES for modern aircraft . . . heavy duty TRANSMISSIONS for Ordnance and Commercial vehicles . . . DIESEL LOCOMOTIVE PARTS . . . PRECISION BEARINGS for aircraft, Diesel locomotives and special application.



Proving Ground FOR WASPS

There's no easy way to create a new aircraft engine. *Better designs* for the famous Wasp engines come only after long research — an endless quest for perfection.

That is why we have quadrupled our test and development facilities since World War II . . . why we have built, and are even now expanding, the world's largest privately-owned turbine laboratory.

If you would like to work for the company with a future — in an industry with an unlimited future — set your sights on Pratt & Whitney Aircraft.

MORE AIRCRAFT ENGINES BEAR THIS EMBLEM THAN ANY OTHER.

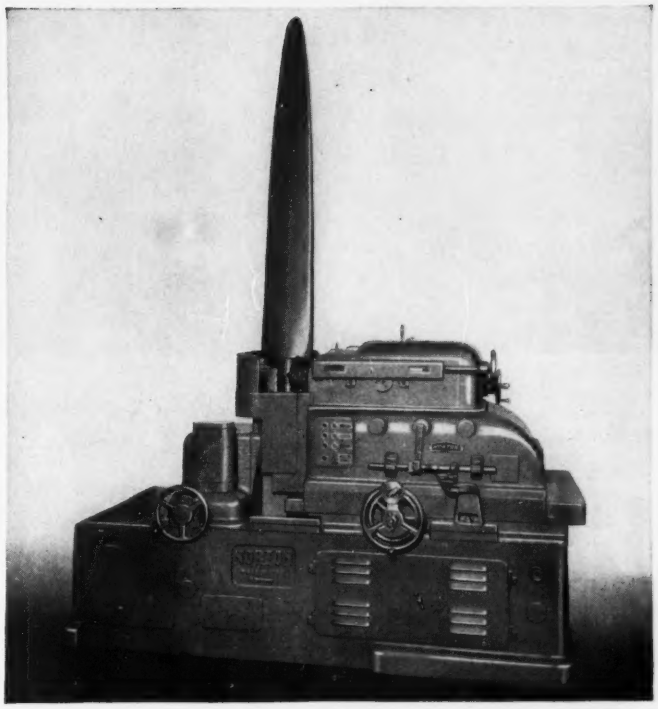
Pratt & Whitney Aircraft's Multi-million dollar Willgoos Laboratory

Pratt & Whitney Aircraft
DIVISION OF UNITED AIRCRAFT CORPORATION

EAST HARTFORD 8, CONNECTICUT U.S.A.

What Is this Machine?

- ☐ *a vertical miller*
- ☐ *a grinding machine*
- ☐ *a broaching machine*
- ☐ *a contour shaper*



It is a grinding machine — specifically, the new Norton Propeller Blade Hub Grinder, used to grind the external surfaces of the hubs of aircraft propeller blades

A Typical Norton Development

This specialized Norton machine brings unusual efficiency to propeller grinding operations. As shown, the propeller blade is held *vertically* — by a workholding fixture on a work spindle with an anti-friction bearing — a new departure that avoids the errors normally caused by deflection when the blade is held *horizontally*, as in conventional methods.

The new Norton grinder has many other improved features adding up to greater speed, accuracy and simplicity of operation. And it requires considerably less floor space than do horizontal machines adapted for the same purpose.

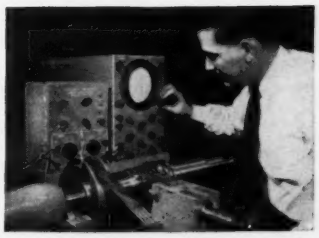
The Broadest Line

The Norton line of grinders and lappers is the most complete offered by any single manufacturer. It runs from small machines for the tool room to high precision, high volume units for heaviest production line duty. Equipped with Norton abrasive wheels these machines form unbeatable combinations for efficient, economical grinding.

To Future Technicians

As the world's largest manufacturers of abrasives and abrasive products, Norton supplies basic tools to all industry. To young men now planning ahead, a career with Norton offers exceptional opportunities for "making better products to make other products better."

Free Booklet describes and illustrates representative types of Norton grinding and lapping machines. Write for your copy.



Guy D. Metcalf, B. S., E. E., Worcester Polytechnic Institute '49, checks smoothness of master cam spindle with specially designed electronic equipment — in connection with his work on Norton cam and contour grinders.

NORTON

TRADE MARK REG. U. S. PAT. OFF.

Making better products to make other products better

ABRASIVES · GRINDING WHEELS · OILSTONES · ABRASIVE PAPER & CLOTH

REFRACTORIES, POROUS MEDIUMS & LABORATORY WARE · NON-SLIP FLOORING

GRINDING & LAPPING MACHINES · BORON CARBIDE PRODUCTS

NORTON COMPANY, WORCESTER 6, MASSACHUSETTS

BEHR-MANNING, TROY, N. Y. IS A DIVISION OF NORTON COMPANY

School of Civil Engineering

1. Pfister, H. J.
2. Eddy, S. M.
3. Bishop, W. K.
4. Estabrook, F. F.
5. Schwartz, R. J.
6. Priest, M. S. (Class Advisor)
7. Kuhn, H. A. J.
8. Lalee, M. Y.
9. Daniels, R. C.
10. Ghazoul, K. N.
11. Gons, L. R.
12. Hunt, J. A.
13. Bolender, H. W.
14. Rauchfuss, D.
15. Hamilton, H. J., Jr.
16. Goldman, L. J.
17. Blanchard, P.
18. Scott, J. G., Jr.
19. Brooks, G. R.
20. Greene, M. C.
21. Drosendahl, R.
22. Meigs, W. L.
23. Kohm, J. C.
24. Melanson, A. L.
25. Burnett, W. C.
26. Barney, K. R.
27. Henn, D. E.

CLASS OF 1953

Department of Engineering Physics

1. Harrison, W. A.
2. Smith, L. P., Director
3. Sack, H. S., Class Advisor
4. Ordway, D. E.
5. Josephson, B., Jr.
6. Knowlton, K. C.
7. Gourdine, M. C.
8. Wong, T.
9. Orr, W. H.
10. Stolz, M., Jr.
11. Rosa, R. J.
12. Wade, J. W.
13. Castner, T. G., Jr.
14. Wolga, G. J.
15. Keiper, D. A.
16. Miles, M. E.

Opportunities in the Oil Industry

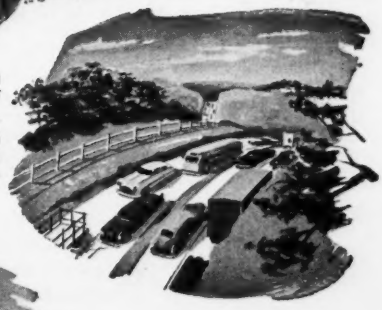
Prospects are good for young men who choose careers with Phillips Petroleum Company.

Phillips Petroleum Company has always been primarily a producer, refiner and marketer of fuels and lubricants. But today, thanks to the versatility of petroleum hydrocarbons, we offer many other opportunities for the technical graduate.

We are engaged in the manufacture of such diversified products as carbon black, butadiene, anhydrous ammonia, synthetic rubber, sulfur compounds, cyclohexane and vinylpyridines. Prospects are good for the still further diversification of products which we can manufacture from petroleum and petroleum gases.

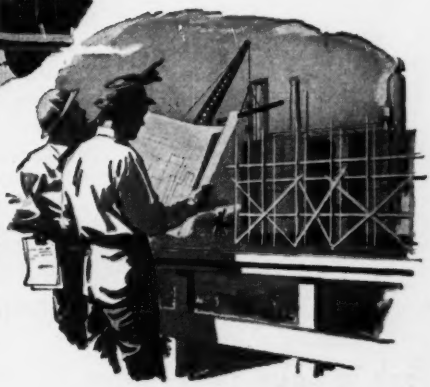
Of the more than 22,000 employees of Phillips Petroleum Company, some 2,200 are technical graduates. Prospects for the technical graduate in the petroleum industry are better than ever. We invite you to write to our Employee Relations Department for information about opportunities with Phillips.

Dress fabrics, synthetic rubber, fertilizers, are a few of the many new products born of the science of petrochemistry as practiced by Phillips Petroleum Company.



Automotive fuels and lubricants are still the *primary* business of Phillips. The vast increase in automotive registrations since 1946 (from 33 million to over 51 million) means expanded opportunities for technical men in this field.

The tremendous consumption of petroleum products demands increased production of crude oil and natural gas. This provides good opportunities for geologists and production men.



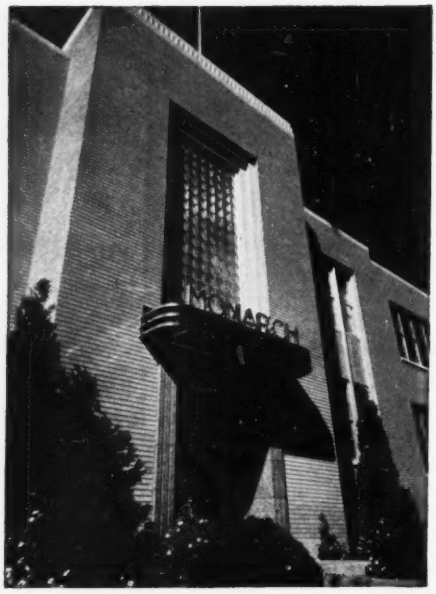
Phillips has tripled its refining capacity in the past seven years. To construct and operate these refineries requires engineers and scientists of the highest competence.

Phillips 66

PHILLIPS PETROLEUM COMPANY

Phillips Chemical Company a Subsidiary

Bartlesville, Oklahoma

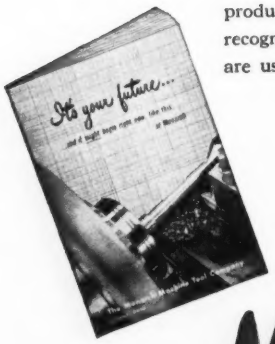


After Graduation— What?

An opportunity exists here at The Monarch Machine Tool Company for several exceptionally well-qualified mechanical, electrical and hydraulic engineering graduates of your class. Mightn't one of these men be you?

The vigorous and vital machine tool industry — keystone of our country's productive power — offers a special satisfaction to its engineers. This is due partly to the basic, sweeping impact of our industry's products; partly because of its continuing program of product development. Inquiry will show you that this is especially true at Monarch, where we specialize in designing and building lathes with a world-wide reputation — with special emphasis on Tracer Control systems for improving accuracy and rate of output.

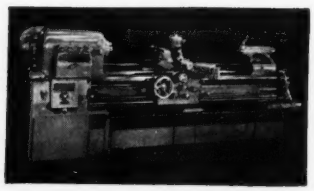
We are in the upper bracket of our industry in size — in the top bracket in product reputation and thus in healthy growth. Engineering talent receives full recognition here. Engineering achievement here makes itself felt wherever lathes are used.



WRITE FOR YOUR FREE COPY OF THIS BOOK!

As we have said, our constant growth means that there will be several openings at Monarch for qualified members of your class. We've prepared this illustrated booklet to give you the Monarch story in more detail than we can do it here. Send for your free copy now. Just address your request to Mr. Kermit Kuck, Vice President — Engineering . . . *The Monarch Machine Tool Company, Sidney, Ohio.*

Monarch
ACCURACY • ECONOMY • LONG LIFE
TURNING MACHINES



FOR A GOOD TURN FASTER . . . TURN TO MONARCH

. . . because of instrumentation

a challenging career with limitless future

In every laboratory . . . every production line . . . every manufacturing plant . . . instrumentation, the newest of sciences, is turning tomorrow into today by speeding the development of new concepts into workable reality. Through the use of modern methods of measurement and control, another industrial revolution is already in the making. The "automatic factory" is more than a vision; it is on the threshold of practical accomplishment.

You can become a part of this dynamic, fast-growing future, by choosing a career in instrumentation with Honeywell—"First In Controls." If your interest lies in research, you'll find Honeywell's laboratories full of stimulating opportunities for developing new and better ways to measure and control. If you want a career in design, your technical skills will be able to expand to their fullest, in working out ways to apply revolutionary new principles to an endless variety of industrial problems. If you prefer industrial engineering, Honeywell's modern factories offer wide opportunity for advancement in this growing profession. And if you want a sales career, you'll join the world's largest organization of its type with a reputation for advanced marketing methods.

Contact your college placement office for additional information or write to:

MINNEAPOLIS-HONEYWELL REGULATOR CO., Brown Instruments Division, Personnel Department, 4599 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

Constellation Orion—*photograph by L. P. Tabor, Cook Observatory, University of Pennsylvania*

STRESS and STRAIN...

English prof: "Correct this sentence: 'Girls is naturally better looking than boys.'"

Wise Frosh: "Girls is artificially better looking than boys."

* * *

Her lips clung tenaciously to his . . . once more she had forgotten to remove her chewing gum.

* * *

Pledge: "Gee, Fred drinks something awful."

Brother: "Yeah, I've tasted it."

* * *

Customer: "What kind of pie is this?"

Waitress: "What does it taste like?"

Customer: "Putty."

Waitress: "Then it's apple. The peach tastes like glue."

* * *

A man wandered into a tennis tournament the other day and sat down on the bench.

"Whose game?" he asked.

A shy young thing sitting next to him looked up hopefully.

"I am," she replied.

* * *

Student: "Why didn't I make a hundred on that history exam?"

Professor: "Do you remember the question of why the pioneers went into the wilderness?"

Student: "Yes."

Professor: "Well, your answer, while very interesting, was incorrect."

* * *

He: "You're not afraid of the big bad wolf?"

She: "No, why?"

He: "How odd. The other three pigs were."

* * *

"Yes, this is a nice little apartment, but where is the bath?"

"Oh pardon me! I thought you were one of those engineering students who wants the place just for the winter."

Men are what women marry. They have two hands, two feet, sometimes even two wives . . . but never more than one idea or one dollar at a time. They are made of the same material, the only difference being that some are better disguised than others.

Generally speaking, they may be divided into three classes: husbands, widowers, and bachelors. A bachelor is an eligible mass of obstinacy surrounded by suspicion. Husbands are of three types: prizes, surprises, and consolation prizes. Making a husband out of a man is one of the highest forms of plastic art known to civilization. It requires science, sculpture, common sense, faith, hope, and charity—but mostly charity.

If you flatter a man, you frighten him to death. If you don't, you bore him to death. If you permit him to make love to you, he gets tired of you in the end; and if you don't, he gets tired of you in the beginning.

If you agree with him on everything, you cease to interest him. If you argue with him, you cease to charm him.

If you believe all he tells you, he thinks you are a fool; and if you don't, he thinks you are a cynic.

If you wear gay colors, rouge, and a startling hat, he hesitates to take you out. But if you wear a brown beret and a tailored suit, he takes you out and stares all evening at the woman in gay colors, rouge, and a startling hat.

If you are the clinging-vine type, he doubts whether you have a brain in your head—and if you're a modern, advanced, and independent woman, he doubts whether you have a heart. If you are silly, he longs for a bright mate. If you are intelligent, he longs for a playmate.

Man is just a worm in the dust. He comes along, wiggles around for awhile, and finally some chicken gets him.

Speaking of Girls—

When one is mentioned here are some of the things the boys want to know:

Fine Arts Student: "What plays has she seen?"

Business Student: "Is she the business type?"

Journalist Student: "What did she ever write?"

The Engineer: "Where is she?"

* * *

Registrar: When were you born?

No reply.

Registrar: I say, when was your birthday?

Freshman Engineer: Wot duh you care? You ain't gonner gimme nothin'.

* * *

During the holidays, two students from the same town met back in the old home burg.

"Say," said the first, "aren't you working your way through college?"

"Yes," replied the second, "I'm editing the college humor mag, but don't tell my mother. She thinks I'm bootlegging gin and peddling marajuana cigarettes."

* * *

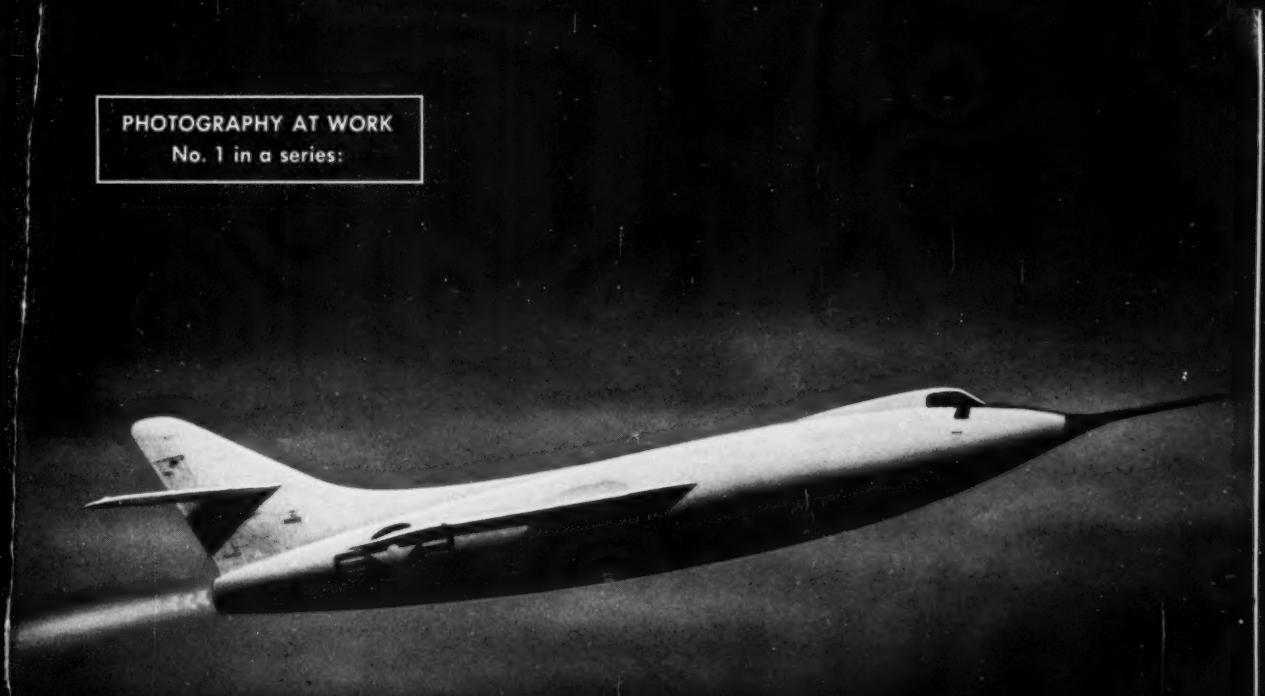
Slowly, her eyes glowing with a soft, mysterious inner light, the beautiful girl raised the glass on high, exulting: "Sherry wine to me is the nectar of the gods, the very elixir of life! When I imbibe its amber delights, my soul begins to throb and burn. The music of a thousand muted violins whisper softly in my ear and I am transported to a make believe world of magic. On the other hand—Port makes me burp."

* * *

The automobile motor began to pound, and finally stopped. The worried boy friend said to his companion: "I wonder what that knock could be?"

"Maybe," said the blonde girl friend, "it's opportunity."

PHOTOGRAPHY AT WORK
No. 1 in a series:



New plane hits 1238 miles per hour!

Camera and film joined in helping produce this Douglas D558-2, which has broken all records by climbing to 14½ miles altitude and reaching 1238 miles per hour.

. . . to speed production, cut costs, here's how the Douglas Aircraft Co. uses Photography throughout its plants

LIKE thousands of other manufacturers and businesses—large and small—Douglas knows the camera is a short cut to greater production at lower cost.

So, from the time a new employee is welcomed to a plant by motion pictures, until a finished plane is on the ramp ready for delivery, photography is hard at work—training workers, testing metals, checking stresses, reproducing drawings, making records, and speeding work in the business offices.

There are countless ways photography saves time and cuts costs. Any business profits when photography gets to work.

There are so many ways photography aids engineering and so many new applications being found, that many well-qualified graduates in the physical sciences and in engineering have been led to find positions with the Eastman Kodak Company.

If you are interested, write to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, New York.

FUNCTIONAL PHOTOGRAPHY

. . . serves industrial, commercial and scientific progress

Kodak

MY QUESTION TO THE G-E STUDENT INFORMATION PANEL:

"What opportunities are available in General Electric for a career in manufacturing?"

. . . EARLE E. WARNER, U. of Illinois, 1952

The answer to this question, presented at a student information meeting held in July, 1952 between G-E personnel and representative college students, is printed below. If you have a question you would like answered, or seek further information about General Electric, mail your request to College Editor, Dept. 123-2, General Electric Co., Schenectady, N. Y.

G. C. HOUSTON, *Manufacturing Services Division* . . . In General Electric manufacturing operations involve supervising and administering the activities of more than 100,000 men and women in more than 100 plants. This includes the operation of approximately 75 distinct product businesses, producing some 200,000 different products ranging from heavy industrial equipment to precision instruments and consumers' goods.

The cost of manufacturing our products represents 70% of the total expenditure for all operations including research, engineering, marketing and other administrative functions.

With these activities and expenditures in the field of manufacturing one can readily visualize the breadth of opportunity in the area of manufacturing. This wide scope of manufacturing activities and the importance of their integration into an effective organization provide opportunity for challenging and rewarding careers in such areas as follows:

Manufacturing Supervision: The most important part of any manufacturing organization is men—those who apply their varied skills and talents to perform the many tasks involved in the manufacturing process. To direct the activities of these men, to inspire performance, co-operation and teamwork, to provide fair and equitable treatment, to see that work is done in required quantity—on time—and at the lowest possible cost, is the responsibility of Manufacturing Supervision. It offers a challenging and satisfying career for individual growth and development.

Manufacturing Engineering: This is the creative portion of modern manufacturing. It involves interpretation of initial product designs into good manufacturing practices through planning the methods by which a product will be manufactured, specifying and designing machine tools and equipment, and planning and developing new processes. It is vitally concerned with such subjects as plant layout, materials handling, operation planning, and quality control. It requires a thorough knowledge and broad understanding of how these subjects influence the manufacture of a product.

Purchasing: General Electric is one of the most diversified purchasers in the country today, buying material from every industry. Much of this purchasing involves technical problems, and requires a knowledge of sources of supply, market trends, and new products. Many items purchased are components or finished products of other technical industries. Constant contact with price, as well as evaluation of current and long-range raw material supply situations, is another phase of this activity. It is becoming more and more important as a career opportunity for young men.

In addition to the above described areas of opportunity in manufacturing, such manufacturing services as wage-rate determination, production control, inventory management, production planning and development, and materials handling offer opportunity for highly trained specialization and for competent management supervision.

These areas of manufacturing, together with many others, offer the college graduate of today a wealth of opportunity for a challenging and rewarding career.

You can put your confidence in—

GENERAL ELECTRIC

University Microfilms
313 N. First St.
Ann Arbor, Mich.

U.S. Postage
PAID
Ithaca, N.Y.
Permit No. 170